UNIVERSITY OF LIVERPOOL

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IN THE NAME OF ALLAH (GOD) THE BENEFICENT

AND THE MERCIFUL

Uncovering the Emerging Risks from Climate Change Scenarios and Related Climate Change Risk Management in the Building Sector in the UK

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By

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ABSTRACT

Climate Change (CC) is recognised as having a significant impact on human decisions, subsequently affecting human-made networks and social systems. Accordingly, gaining insight into how and when CC-related data is established, distributed and utilised is essential in terms of the design of policies, approaches and systems governing everyday life. Uncovering the impacts and risks associated with CC on building sector assets has been highlighted in other research studies as an area necessitating further work. With this in mind, this study is directed towards considering the risks known to emerge from CC scenarios on UK buildings and real estate, and how buildings may be affected by CC.

This study adopted a critical literature review with the goal of establishing the risks seen to emerge from CC. The study has adopted an online survey in order to explore the opinions and views of professionals and practitioners across several organisations, sectors and institutions in the UK in relation to the risks emerging from CCS. In addition, the research assessed the most likely risks emerging from CCS on buildings and real estate, along with the potential timescale of their emergence, as based on the experience of the respondents of the study. Moreover, the survey was designed empirically to identified—as based on the emerging risks—the possible and practical responses that will form the most effective Climate Change Risk Management (CCRM) strategies and tools to be adopted to cope with these emerging risks and accordingly avoid as much impact as is possible in direct consideration of property.

The main findings from this study showed that, identifying and assessing the emerging risks from CC—specifically in terms of their damages, impacts and emergence timeframe—are crucial for all stages of the lifecycle of buildings and real estate. In this study, 112 risk factors have been identified and were grouped into seven main clusters; from which the operational emerging risks were the most important risks cluster.

On the whole, this study provides a first attempt to uncover the potential emerging risks from CCS on the building sector from different perspectives, using conceptual study and simulation in relation to previous researches, and therefore helps to extend the understanding of the possible risks and impacts emerging from CC. In addition, this study builds knowledge in the building sector by providing the potential emerging risks that need to be integrated within a building's lifecycle in a systematic manner for mitigating the impact of climate change.

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List of Abbreviations

C.V	Coefficient of Variance
CC	Climate Change
CCP	Climate Change Patterns
CCRA	Climate Change Risk Assessment
CCRM	Climate Change Risk Management
CCS	Climate Change Scenarios
FM	Facility Management
GHG	Greenhouse Gases
IAIA	International Association for Impact Assessment
IPCC	Intergovernmental Panel on Climate Change
LCCP	London Climate Change Partnership
LIU	Liberty International Underwriters
LR	Liability and Responsibility
POE	Post Occupancy Evaluation
R.F	Risk Factor
R.M	Risk Management
RAE	Royal Academy of Engineering
S.D	Standard Deviation
S.F	Strategy Factor
UKCIP	UK Climate Impact Programme
UNEP	United Nations Environment Programme

CHAPTER 1: INTRODUCTION

1.1 Introduction

The reasons behind the emergence of climate change scenarios (CCS) are twofold: primarily, frequency phenomena and natural conditions, such as volcanoes; and secondly, the increase of human activities on the earth, especially during the beginning and continuation of the industrial era, which is responsible for the production of huge amounts of greenhouse gas emissions, which is, in turn, the main driver of climate change (McMullen and Jabbour, 2009; Woodward, 2008; Hertin *et al.*, 2003; Changnon, 1995). These drivers of climate change have significantly contributed to the different ways in increasing the frequency of climate change scenarios during recent decades (De Wilde and Coley, 2012; Steenbergen *et al.*, 2012; Garvin *et al.*, 1998; Pretlove and Oreszczyn, 1998). Currently, climate change has become a global phenomenon, and its threats have a huge and variety of risks and impacts across all aspects of life, including the building sector.

Climate change scenarios affect buildings and real estate in several ways and at different levels, such as through direct and indirect emerging risks. These risks emerging from CCS result in threats to assets and increased damages on property, thus leading to preventing buildings and real estate from fulfilling their design and construct roles. Hence, understanding and establishing the separate and collective risks emerging from climate change patterns, and the impacts they have on buildings, are essential for the design and optimal timing of policies, systems, procedures strategies, all of which help assets to deal with and manage such emerging risks and to avoid their impacts and threats. This highlights the importance of uncovering the potential risks emerging from CCS, which is the core of this study.

This research project is a first attempt, combining the detection of the extent of likely emerging risks and the emergence timescale, as previous studies and researches have indicated the need for such a study. Moreover, this research project presents a practical and theoretical classification for describing and identifying the potential risks emerging from climate change scenarios, which will assist professionals, such as architects, designers, constructors, owners and decision-makers, in taking and adopting the best, most suitable and practical strategies or solutions related to their assets. The clustering of risks emerging from CCS, as provided by this research project, are based on the study and analysis of the potential risks stemming from climate change scenarios and impacting the building sector; these are then clustered based on possible emerging risk threats.

1.2 Research Rationale and Problem Statement

The buildings sector is one of the main pillars of development for any country, as well as the tangible evidence of creativity and innovation, whilst also enabling keeping up with modern times—especially in relation to buildings and real estate. However, the emergence of climate change and its spread to become a global phenomenon, which does not recognise the borders of these development and innovations, might be limited. This is the reason behind the many claims centred on the need to address this phenomenon and deal with its threats and risks, recognised as threatening all aspects of life. Amongst these claims, there have been calls to enact regulations and systems on developed countries to reduce emissions of Green House Gases (GHGs), which is the main driver of the emergence of climate change; this resulted in the Kyoto protocol in 1997. The core of this protocol is to obligate countries to follow methods and adopt ways of reducing GHGs emissions in an attempt to overcome the intensity and frequency of risks and impacts form climate change scenarios. The trend of reducing GHGs emissions with the full or partial absence of determining the potential risks of CCS could exacerbate the effects of these risks and accordingly increase the uncertainty of climate change and the risks facing professionals in the building sector—especially in regard to knowledge and awareness of against such risks and how they can be managed through design and construction to ensure the seamless operation and maintenance of such assets.

From a building sector perspective, it is essential to determine the potential risks emerging from CCS on building and real estate in order to face the challenges occurring besides the climatic impacts, and accordingly to protect property from direct and indirect risks. Hence, there is a need, from the outset, to deal with such risks through previous encounters and the experiences of others to work in a scientific and systematic. This has been highlighted and indicated in the work of Hazelwood (2014), who states that there is a need to better understand how the building sector is vulnerable to environmental risks, such as CCS. Moreover, the partnership between academics and partners in the building sector must be supported in order to assist decision-makers with the challenge of managing risks on buildings and real estate from CCS. Moreover, Kwan (2009) claims that it is important to have climate change risks in place so as to drive innovation in the building sector. In addition, Hjerpe and Glaas (2012, p484) state that *"more research is required to build a more thorough understanding of how to move from analysing climate change risks to assessing and managing integrated vulnerability in various cases. An interesting research question examined here is how to develop practical methods that take account of wider stakeholder perspectives"*.

These statements emphasise the importance of identifying the potential risks emerging from CCS on the building sector in an effort to enhance the ability of assets to face such risks in increasing the performance of buildings and real estate, and their related facilities, as well as reaching and achieving the satisfaction of stakeholders, such as occupants, employees, professionals, owners and investors; therefore, Hacker *et al*., (2005), point out that considering and taking into account the risks emerging from CCS and impacting buildings will result in the increased longevity of existing premises, as well as the generation of buildings that are more resilience to such risks and which also have the ability of high-performance.

Moreover, it is important to recognise that the risks emerging from CCS on the building sector will be varied and stationed between direct and indirect risks. According to Garvin *et al*., (1998), who declared that there are numerous significant aspects of potential risks emerging from CCS that require further clarification and identification in order to formulate suitable actions, including strategies and plans against them. Kwan (2009), adds that there are four essential areas of climate change risk, all of which can impact buildings and real estate; these aspects are namely physical, regulation, reputational and litigation. Hence, this research project considers seven groups of potential emerging risks as potentially affecting the building sector in different ways; these clusters are physical, operational, financial, occupant dissatisfaction, liability and responsibility, reputational and regulation emerging risks. The aforementioned motivations were the reasons behind the in-depth research established.

The inclusion of different risks of climate change can be justified by the following significant reasons. Firstly, allowing the gap between designers and architects in relation to CCS emerging risks to be filled through following strategies and criteria, assisting them in designing buildings that are in line with the different conditions of CCS, as well as adapting to the potential risks stemming from such climatic patterns. Secondly, determining the timescale of emergence of these risks could potentially help in organising prioritising and also positively contribute to making the right decision for decision-makers or adopting the best strategies for professionals in the building sector. Thirdly, moving from the analysis phase of the expected climate change risks to the application stage through the adoption and implementation of appropriate strategies and plans, enabling buildings and real estate to adapt to such risks, or possibly altogether mitigate these risks, and accordingly raise their resilience level in facing these risks during the resilience lifecycle of assets.

1.3 The Aim and Objectives of the Research

1.3.1 The Aim of the Research

The main aim of this research project is to discover and establish the risks emerging from climate change scenarios within the building sector, and to determine the timescale of occurrence for such risks, along with related CCRM strategies.

1.3.2 Objectives of the Research

This research project contains several objectives, all centred on fulfilling the main aim. The objectives are as follows:

- To review climate change in terms of its history, background and causes.
- To identify the possible scenarios of climate change associated with the building sector, as well as mapping between climatic scenarios and the building sector.
- To investigate the Emerging Climate Change Risks (ECCR) on buildings and real estate.
- To determine and evaluate the identified risks emerging from climate change patterns, and to cluster them into groups.
- To explore the emergence timescale of risks stemming from CCS.
- To identify the strategies of climate change risk management.
- To design and carry out a quantitative survey (questionnaire).
- To perform statistical analysis and report the results and findings.
- To assess CCS emerging risks in terms of time of occurrence.
- To reveal the most effective climate change risk management (CCRM) factors in relation to managing and controlling such emerging risks.

The methodology adopted in order to achieve these objectives is highlighted and outlined in the following section.

1.4 Research Questions

Several research questions have been devised throughout this study in an effort to achieve the research problem statement. The main research questions are as follows:

- What is climate change?
- What are the history, causes and possible scenarios of CC?
- What are the differences between CC and normal weather?
- What are the views of experts and practitioners in the building sector concerning the reality of climate change?
- What is the relationship between CC and the building sector?
- What are the potential risks emerging from CCS?
- What is the most suitable and systematic way of identifying the emerging risks on buildings from CCS, and how can these be clustered?
- What is the timescale of the emergence of identified emerging risks?
- What is the effective risk management factors able to control the risks emerging from CCS?
- Are there differences between the ranking of the likelihood occurrence of emerging risks and their emergence timescale compared with the ranking based on the type of organisation of respondents and their professional roles?
- Are there significant differences identifiable between the ranking of the effectiveness of CCRM factors compared with the ranking based on the type of organisation of respondents and their professional roles?
- How can the identified emerging risks assist organisations, sectors and professionals in coping with their impacts and damages?
- How can the identified emerging risks improve the performance of buildings and real estate?

1.5 Research Hypothesis

The main hypothesis of this research is centred on the investigation of the likelihood of risks emerging from CCS to occur, and their emergence timescale, as well as exploring the effectiveness of CCRM factors. The hypotheses adopted in this study are tested based on both the ranking of the type of organisation and the professional roles. These hypotheses are as follows:

Ha_0 ($p > 0.05$): there is no significant difference between respondents in terms of the rating for the likelihood of the occurrence of risks emerging from climate change.
Ha_1 ($p < 0.05$): there is a significant difference between respondents in terms of the rating for the likelihood of the occurrence of risks emerging from climate change.

Hb_0 ($p > 0.05$): there is no significant difference between respondents in terms of the rating for the occurrence timeframe of risks emerging from climate change.
Hb_1 ($p < 0.05$): there is significant difference between respondents in terms of the rating for the occurrence timeframe of risks emerging from climate change.

Hc_0 ($p > 0.05$): there is no significant difference among the respondents in terms of the level of effectiveness of CCRM factors.
Hc_1 ($p < 0.05$): there is significant difference among the respondents in terms of the level of effectiveness of CCRM factors.

1.6 Scope of the Research

The impacts stemming from climate change scenarios on the building sector may expand and affect other sectors, and the same in contrast, where the impacts of climate change on related sectors, such as energy sectors, are highly likely to adversely affect the performance of buildings and real estate (Austin *et al*., 2008). According to the latest report from IPCC (2014), across the globe, the risks emerging from CCS are stationed in urban areas.

In this regard, the scope of the research project is centred on investigating and identifying the various potential emerging risks and their timeframe of occurrence as a result of climate change scenarios on buildings and real estate. This is achieved by considering several steps: firstly, investigating the causes of climate change and establishing the possible scenarios that might affect the building sector and incur damage to the buildings, their materials and elements; secondly, identifying the potential risks emerging from CCS that could have a direct impact and might have induce damage on buildings and real estate, or on their elements and components, along with the emerging risks that affect occupants or professionals, such as designers, architects, owners and managers; thirdly, clustering the identified emerging risks in a systematic and practical way; and finally, identifying the associated strategies and plans that could be CCRM tools used in order to manage buildings and real estate with such emerging risks, considering mitigation and adaptation.

A systematic review of the literature in this study, along with previous researches and studies, such as those by Hunt and Watkiss (2011), Martin *et al.*, (2009), Hacker *et al*., (2005) and Crawley (2003), indicated that the possible risks emerging from CCS on buildings remain unclear and very limited. For these reasons, this study project has been considered as the first attempts at uncovering these emerging risks and addressing the relation strategies, which could also be a point of departure for further research and studies.

Moreover, the importance of this research lies in the study and identification of potential risks emerging from climate change patterns and the likely timescale for their emergence, whilst also identifying the factors that help to deal with such emerging risks, which could lie in strategies and plans of climate change risk management.

1.7 Methodology of the Research

This section has illustrated and outlined the research methodology in general; however, the details of the methodology adopted in order to achieve the goals of this study are discussed and presented in the following chapter (Chapter 2).

The research methodology formulated in this study is founded on a systematic literature review and conceptual and simulation of previous studies and researches relating to climate change in terms of its history, causes and possible scenarios (see Chapter 3). Built on this, the potential risks emerging from CCS were identified, as based on previous researches and studies, as well as the determined effective CCRM factors (see chapters 4–11). based on the information and data gathered from the literature review, the inclusive emerging risk factors were identified and designed as a questionnaire in an effort to collect data from expert professionals (see Chapter 3). The questionnaire subsequently was circulated to different professionals, such as risk managers, facility managers, environment managers and other experts in the field, all of whom were employed in different sectors and organisations in the UK, including universities, hospitals, housing associations and institutions. The participants of the survey were asked to rank the emerging risk factors through the use of a Likert scale, considering the timescale of the likelihood of the occurrence of such emerging risks. The data collected were analysed and processed using SPSS software and Microsoft Excel software. This part of the research highlights the importance of the identified risk factors, such as those of greater concern amongst the respondents, and those of lesser concern, or those inducing disagreement amongst the participants (see chapters 12, 13 and 14). The agreements and disagreements in the findings were discussed and linked to the literature review (see Chapter 15). Built on these, the recommendations and further areas of future researches and studies were extracted and presented (see Chapter 16).

1.8 The Significance of the Research

It is widely acceptable that the frequency and magnitude of climate change scenarios is predominantly concerned with the ongoing escalation, which leads to an increased likelihood of the emergence of emerging risks and impacts on the building sector in particular, which, in turn, will suffer from negative impacts on the lifecycle and performance of buildings and real estate. From this point, researchers in this field will direct more attention and focus to the physical risks. This fact is supported by Martin *et al.*, (2009), who confirmed that the physical risks arising from CCS on the building sector are well recognised. However, the associated emerging risks, such as operational and financial factors, combined with the linkage between the likelihood of occurrence of such risks and the timescale of their emergence, remain unexplored from a practical and an empirical perspective.

It seems, when reviewing the extant researches and studies, that there is a lack of comprehensive and clear vision for the aspects of the effects of climate change risks on assets. This shortcoming has focused on the lack of knowledge and awareness in terms of the concept, severity and type of risks emerging from CCS, and the link to the occurrence timescale of the emergence of such risks on buildings and real estate. This, combined with the absence of structure of the required and expected responses (especially from officials, such as advisors, decision-makers, and other professionals, such as designers, architects and managers in the building sector) to such risks, is represented in the legislation of regulations and the application of the effective strategies and plans centred on mitigating the effects of these emerging risks on property. Here lies the importance and significance of this research project, most clearly visible when considering its focus on the exploration and identification of all of the risks resulting from CCS on buildings and real estate, and determines their occurrence timeframe, as well as the effective strategies of CCRM. This research will be useful in assisting professionals in the building sector, such as designers, architects, constructors, managers and owners, in a number of different ways. For example, it may be that this study increases professionals' awareness about the risks stemming from CCS and their impacts; this knowledge could assist them in choosing a practical process for dealing with such risks in an effort to adapting present buildings. Additionally, all of these determinants will positively contribute to increasing creativity across the building sector—especially in future projects in terms of design, operation and management, or even maintenance.

1.9 Thesis Outline

The flowchart presented in Figure 1-1 illustrated the structure of this thesis, whilst the following presents a brief outline for each chapter.

Chapter 1: This chapter introduces the research project, including the justification behind the completion of this study, the scope of the study, the aim and objectives of the study, and a brief overview of the methodology adopted, as well as the significance of the study. Moreover, the structure of the thesis is presented.

Chapter 2: This chapter presents the research methodology adopted, which is divided into two parts: the first part reviews the approaches and methods of research, whilst the second part highlights the research method selected, and details its justifications, as well as the process of the questionnaire design.

Chapter 3: This is the first chapter in the Literature Review stage. This chapter reviews climate change in terms of its history, background, causes and scenarios. The different views from experts, researchers and others parties of interest are presented in specific regard to climate change and its reality. Moreover, the association between CCS and the building sector is discussed.

Chapter 4: This is the second chapter of the Literature Review, but is the first chapter discussing the risks emerging from CCS. This chapter considers the physical risks on buildings and real estate, known to impact these areas and incur damage on property or their elements and components.

Chapter 5: Focus is directed towards the operational emerging risks that have negative impacts on the processes and lifecycles of the operation and performance of buildings and real estate. It is initiated through reviewing the operational processes within buildings in order to reach the potential operational risks. This chapter uncovers the operational risks emerging from three different operational phases in the building sector, including risks on facility management, energy supplier, and maintenance and replacement activities.

Chapter 6: This chapter investigates the costs of the emerging risks on the building sector as direct consequences of CCS on buildings and real estate, and identifies the financial risks emerging from these scenarios, including changing temperatures and extreme events of climate change.

Chapter 7: Illustrates the potential risks emerging from occupant dissatisfaction. This chapter discusses the post-occupancy evaluation in terms of its definition, importance and factors in an effort to determine the possible risks emerging from CCS associated with the satisfaction of buildings' occupants.

Chapter 8: This chapter is divided into two sections: firstly, there is focus directed towards the liability risks arising from the impacts of CCS; and secondly, the responsibility of professionals in the building sector in terms of the methods and systems followed or adopted to cope with such climatic emerging risks.

Chapter 9: This chapter discusses and presents the reputational risks stemming from CCS. This section applies three elements in an effort to identify the reputational risks arising from CCS; these are economic, social and occupant in nature, and are considered to be the main drivers of the emergence of reputational emerging risks.

Chapter 10 is the last chapter of the fundamental Literature Review, and identifies the risks emerging from CCS. This chapter reviews the correlation between regulations and climate change patterns within the building sector. It presents the arising potential emerging regulation risks and the importance of avoiding the impacts of climate change.

Chapter 11 is the last chapter in the Literature Review phase of the research. This section explores the CCRM factors assisting in coping with risks emerging from CCS. These indicators are grounded into three clusters of CCRM factors, namely strategies, process and planning factors.

Chapter 12 presents the findings from the questionnaire and presents the first results of the data analysis using the various softwares chosen for use in this research project. Moreover, this chapter presents the risk indicators in a statistical way and based on the ranking of participants for each factors in an effort to be used in the following analysis chapters.

Chapter 13 presents the ranking results of the data findings from the survey and orders them based on several determines, such as the likelihood of their occurrence, the timescale of their occurrence for the emerging risks, and the level of effectiveness for CCRM factors. Moreover, the ranking results are based on the views of respondents, and are presented as based on the ranking within the group or overall, the type of organisation, and the professional roles.

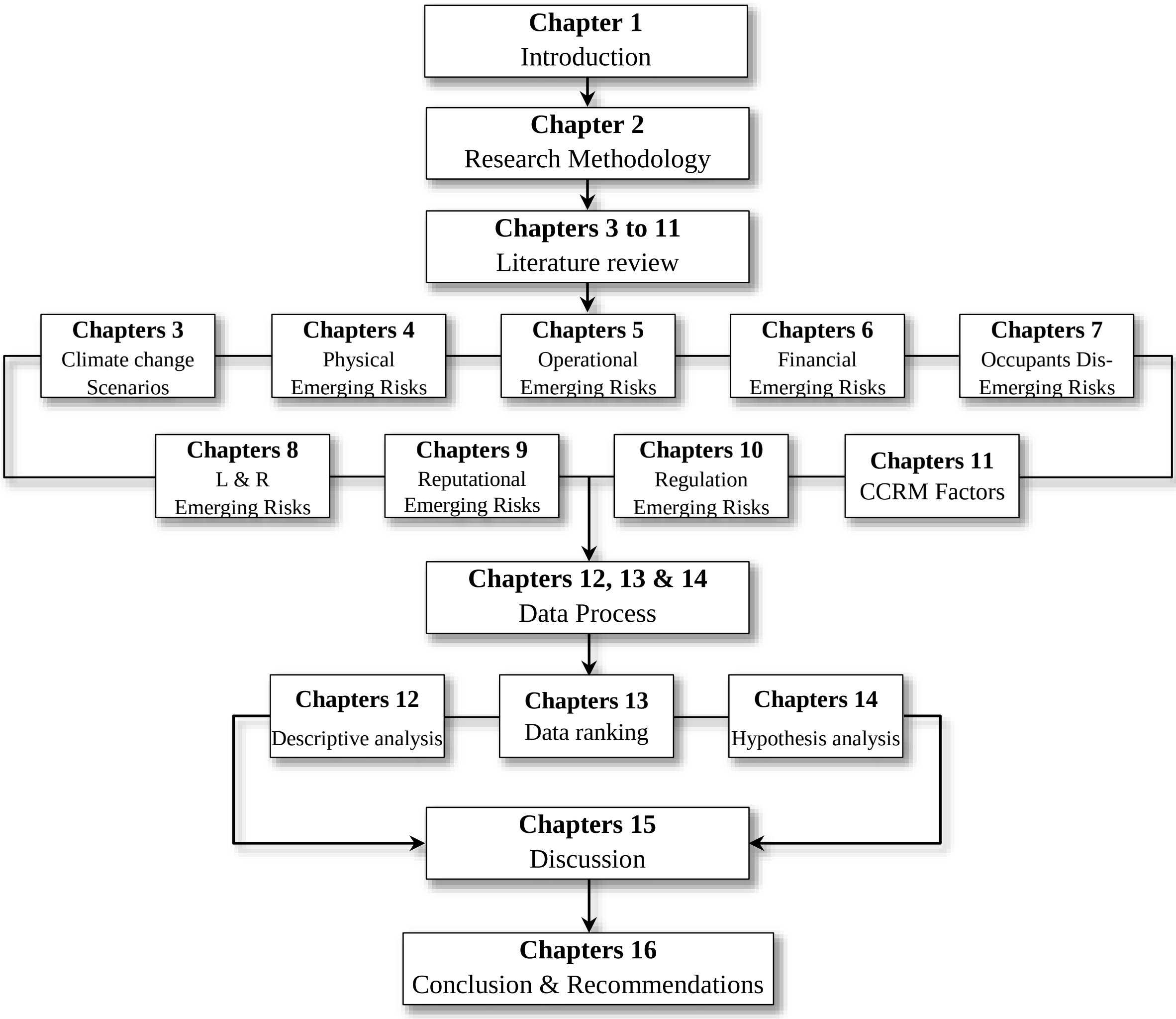

Figure 1-1 Structure of Thesis

Chapter 14 provides the results of the hypothesis test using one-way ANOVA. Moreover, the multiple Comparisons Post Hoc test by Tukey HSD is carried out in order to establish the differences in the respondents group due to the significant difference results from the ANOVA test. These tests are useful in establishing the research hypotheses that are rejected and accepted.

Chapter 15 provides a discussion of the findings by comparing the findings from both the data analysis and literature review, combined with the compatibility and incompatibility of related studies and researches.

Chapter 16 presents the research project as a whole, and highlights the contributions, research limitation and recommendations for further study and research.

CHAPTER 2: RESEARCH METHOD

2.1 Introduction

The method and techniques adopted by research assist in fulfilling the research achievements. Designing a good research methodology is essential when seeking to assure the validity of the research (El-Diraby and O'Conner, 2004). This chapter is dedicated to discussing and illustrating the basic concepts, principles and methodologies associated with research philosophy; there will be the inclusion of the method adopted in order to achieve the aims and objectives of the research project. Importantly, the primary aim of this chapter is to provide a general outline of the study approach, as well as the research technique descriptions, the types of data and their respective data collection methods, in addition to the ways in which data can be analysed. With consideration to all of these areas, the research aims and objectives will be achieved.

2.2 Research Methodology Concept

The Oxford Dictionary defines research as '*the systematic investigation into and study of materials and sources in order to establish facts and reach new conclusions'* (Stevenson, 2010). In addition, Longman dictionary (2013) defines research as *'serious study of a subject, in order to discover new facts or test new ideas'*.

Furthermore, Leedy (1989, p.5), defines research as, *'A procedure by which we attempt to find systematically, and with the support of demonstrable fact, the answer to a question or the resolution of a problem'*. Research can be defined as *'something that people undertake in order to find out things in a systematic way, thereby increasing their knowledge'* (Saunders *et al.*, 2012). Keshvyer (1973, as cited in Krishnaswamy and Satyaprasad, 2010) defines research as *'systematic, controlled, empirical and critical investigation of hypothetical propositions about the presumed relations among natural phenomena'*. Hence, research is concerned with the use of specific research methods (systematic technique) in an effort to test or establish new ideas, facts and solutions to widen knowledge or resolve problems. In addition, the term 'methodology' refers to *'the theory of how research project should be undertaken'*; in contrast, the term 'method' is centred on *'the techniques and procedures which used to obtain and analysis data'* (Saunders *et al.*, 2012). Quite simply, the research methodology refers to the technique adapted for the collection of data, including interviews, questionnaires and participant observations (Bryman and Bell, 2003).

2.3 Research Design

The research design is a context providing a framework within which the collection and analysis of data is included in an effort to answer research questions (Bryman and Bell, 2003). Research design may be defined as the general plan and framework of different research components brought together, such as literature review, research questions, the collection and analysis of data, and findings—all of which comes together to achieve the final goals of the study (Royer and Zarlowski, 2001; Tan, 2004; Saunders *et al.*, 2012).

Importantly, this means that the research design illustrates the most appropriate and suitable methods to be used to review research aspects, and to collect and analyse data.

2.4 Research Approaches

The research approach is an important stage for selecting the type of approaches needing to be implemented in order to collect and analyse data (Fellows and Liu 2003). The research approach tends to be qualitative or quantitative, or otherwise a combination of the approaches; this is known as a mixed-method approach, combining both quantitative and qualitative (Creswell, 2014).

The three research approaches will be discussed and illustrated in the following section. This will be flowed with an explanation and justification of the chosen approach, as adopted in this research project.

2.4.1 Quantitative Approach

The quantitative approach is associated with positivism, and seeks to collect factual data in an effort to study relationships between facts, which are then compared with previous theories in order to test or develop theories (Saunders *et al.*, 2012). Quantitative methods are recognised as more practical and accurate approaches as they are adopted in mind of gathering information and data pertaining to easily calculable items. Nonetheless, quantitative research can also be carried out when conducting studies in areas that are predominantly qualitative

(Moore, 2000). Generally, quantitative research is referred to as being more traditional or experimental, with such methods used to identify relationships between measured variables in order to explain, predict and control phenomena (Leedy and Ormrod, 2005).

The data gathered is most likely to be raw, in-depth and unstructured in nature, meaning that the data collected needs to undergo filtering and sorting, amongst other things, in order to facilitate examination. Overall, data analysis, in this context, is simpler when utilising qualitative data, as highlighted by scholars Fellows and Liu (2003).

2.4.2 Qualitative Approach

Bryman (2008) suggests that research that is qualitative in nature may be centred on description and explanation through making use of ‘How?’ and ‘Why?’ questions, which facilitates the gathering of in-depth data relating to the social world under examination. Moreover, qualitative approaches are more centred on gaining insight into rich descriptions and their associated concepts and theories (Ritchie and Lewis, 2003). Importantly, it is also stated by Marshall and Rossman (1999) that there are three major purposes for research when implementing qualitative methods: these reasons may be recognised as garnering understanding, developing or discovering.

Quantitative	Qualitative
Objective	Subjective
Deals with numbers	Deals with descriptions
Point of view of researcher	Point of view of social actors
Researcher distant	Researcher close
Test theory	Develops emergent theory
Static	Process
Generalisation	Contextual understanding
Hard, reliable data	Rich deep data
Artificial settings	Natural settings
Data can be observed but not measured	Data can be measured
Research questions: How many? Strength of association	Research questions: What? Why?
Researcher is separate	Researcher is part of process
Establishes relationships	Describes meaning
Formal voice, scientific style	Personal voice, literary style
Focused	Holistic
Known variables	Unknown variables
Established guidelines	Flexible guidelines

Table 2.1 The Differences between Qualitative and Quantitative Approaches;

Adapted from Bryman & Bell 2003; Leedy & Ormrod, 2005; Andrson, 2006.

In addition, the objective behind the application of the qualitative approach in research is to investigate and examine the study area, which needs to be carried out without prior formulation in an effort to develop insight into, and to facilitate gathering, data and information (Fellows and Liu, 2003). Additionally, qualitative research is connected with the generation of theories (Bryman and Bell, 2003; Fellows and Liu, 2003).

At the most basic level of research, a qualitative approach is applied first in the research in order to tease out ideas, which then can be translated into question forms that may be tested in a quantitative way (Shields and Twycross, 2003). Table 2.1 above details the key differences between quantitative and qualitative approaches.

2.4.3 Mixed Methods Approach

Nowadays, the combination of qualitative and quantitative approaches be very common and significant, as it is very important in order to acquire deep findings and understanding, which then contribute in making inferences and assisting in drawing conclusions (Fellows and Liu, 2003; Andrson, 2006). It is useful for a mixed-method approach to be used in tandem in order to provide measurements for comparison and evaluation, and to give in-depth explanation of the meaning and answers of ideas and questions of the research, sequentially (Shields and Twycross, 2003). Combining two research approaches is concerned with helping researchers to use multiple sources of data in order to investigate the research problem, which then will lead to enhancing and improving the levels of confidence of subsequent findings (Bryman and Bell, 2003).

Andrson (2006) states that the combination of methods is referred to as triangulation or pluralistic research; the advantages of this approach are as follows:

- It helps to develop the research.
- It can increase validity.
- It provides complementarities.
- It creates new lines of ideas and thinking through the emergence of the latest perspectives and contradictions.

2.5 Adopted Research Methodology

The previous section reviews the theoretical basis for the types of research approach. Building on these advantages, a hybrid method was selected for use in this research in order to achieve the research aims and objectives. This mixed approach includes several tasks, such as literature review and the design of a survey, and the collection and analysis of data. The following part is dedicated to illustrating and discussing the details of the adopted research methodology, which will then lead to conducting the research. In addition, the techniques and process followed in the research project for gathering and examining data will be discussed in detail. Figure 2-1 below provides a general outline of the study approach, including all phases, parts, chapters, tasks and subtasks adopted and followed in the research.

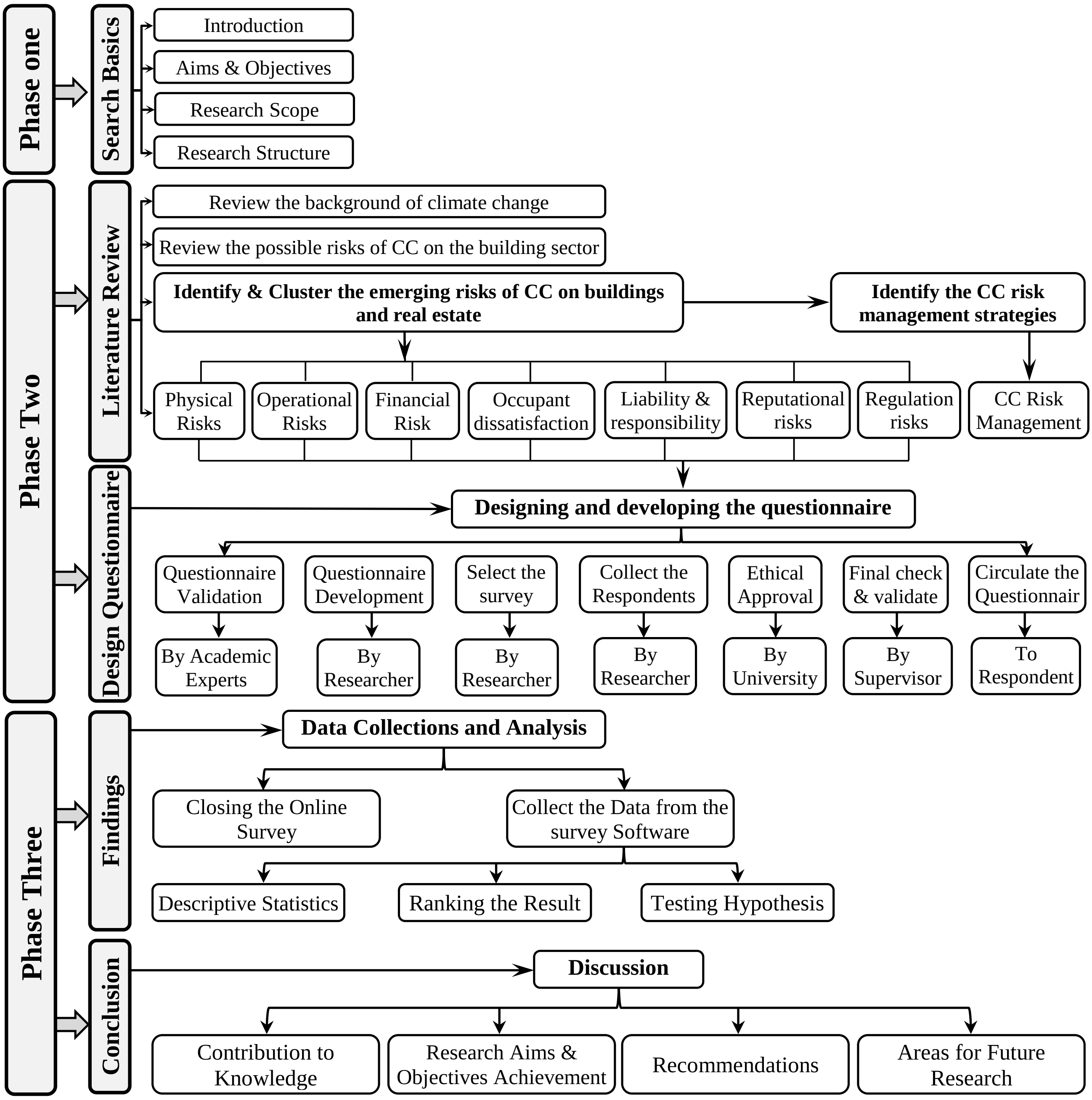

Figure 2-1 The Research Methods Process

2.5.1 Research Methods Process

This part is focused on highlighting the methods and tasks that have been adopted throughout the stages of this research project in order to establish the aims and objectives of the study. These tasks include the following phases, starting with a literature review and ending with data analysis for the findings.

2.5.2 Critical Literature Review

The main function of the literature review is to ascertain the existing level of knowledge related to the research topic, as well as to increase the knowledge of the researcher relating to the research study area. The literature review can be referred to as the cornerstone of the research project as it helps to highlight the concepts and theories relevant to the area of research. Additionally, it assists in understanding the consequences of preceding research and an appreciation of the context in which the topic area exists. These will lead to identifying any gaps of knowledge that need to be investigated and searched. Moreover, at the early stages of the research project, it is essential to employ an investigation and search for any potential related theories and literature. Furthermore, the literature must be considered in the context of theory (Fellows and Liu, 2003). According to Hart (1998), the following are the purposes of reviewing literature:

- Identify what has been established in the field of research.
- Gain access to important variables related to the search area.
- Discover new research perspectives.
- Find relationships between practice and ideas.
- Determine the research area to obtain the research problem or question.
- Identify and improve the subject vocabularies.
- Connect ideas with various theories.
- Identify methodologies and research techniques.
- Provide a chronology of the subject to show correlation(s) with developments and changes.

In this research project, a comprehensive literature review was employed in order to find the risks factors emerging from climate change in the context of buildings and real estate. The literature review was carried out with consideration to both theoretical and empirical researches. In addition, an investigation of data, from journals, textbooks, newspapers, government reports and publications specialising in internet websites and conferences, was undertaken. This was done initially by looking through a literature review on the historical knowledge and background of climate change in terms of its concepts, causes and scenarios, and illustrated different views about it. Additionally, the emerging risks and impacts of climate change scenarios were illustrated and discussed as an important stage of the literature review. Built on this, a comprehensive investigation was carried out in mind of obtaining sufficient information relating to the emerging risks of climate change on buildings and real estate; such risks were identified and classified into clusters. These form the foundation of the research project.

2.5.3 Questionnaire Survey

Generally, a questionnaire adopts one of two different approaches: one is when respondents record their own answers; the other involves respondents answering the questions during virtual interviews or over the telephone (Saunders *et al.*, 2012). Moreover, Leedy and Ormrod (2005), state that a questionnaire survey involves acquiring information from groups of people via asking questions and tabulating their own answers, which might include their own characteristics, opinions, attitudes, behaviours and previous experience.

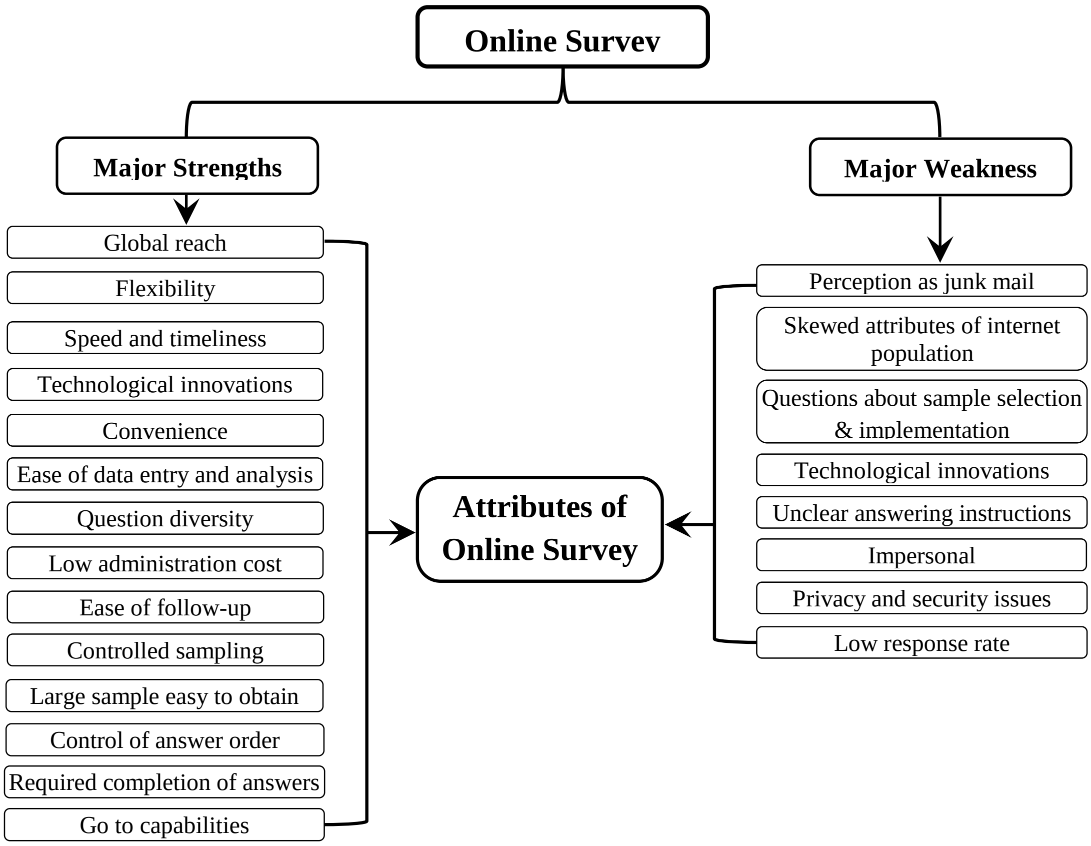

Figure 2-2 The Strength and Weakness of Using Online Survey; Adapted from Evans & Mathur (2005); p.197.

The questionnaire survey involves groups of questions designed to gather data in order to obtain the research aims and objectives. Usually, the questionnaire consists of two different types of question: open and closed. In the case of open questions, respondents' answers fall into different forms, may encompass more detail, and might present different content. Moreover, answers might be extended and diverge from the research topic. Although open questions are easy to pose, the answers tend to be more difficult to understand and analyse, and may not be complete. In contrast, however, closed question constrain participants' responses to a limited number of possible answers, predetermined as written by the researcher. Hence, the responses to closed questions are easier and quicker to analyse (Fellows and Liu, 2003). The main emphasis of questionnaires is centred on fact-finding, meaning they are a good way of collecting data and information both quickly and relatively inexpensively (Bell, 2005).

As a further consideration, during the 20th Century, online surveys become more practical and scientific due to great advances in the techniques and technologies utilised in survey research. The use of online questionnaires comprises numerous advantages and potential disadvantages, as illustrated in Figure 2-2 above (Evans and Mathur, 2005). Moreover, normally, the design of a questionnaire progresses through two different stages, as demonstrated in Figure 2-3 (Quee, 1999).

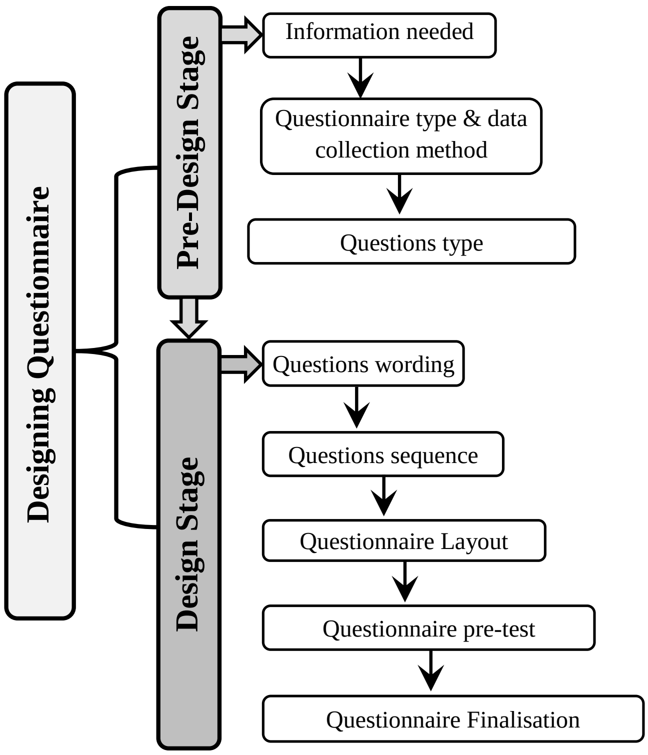

Figure 2-3 Procedures for Designing Questionnaire; Adapted from Quee, (1999); p.134.

Based on the above explanation this research focuses on four parts when designing the online survey as presented in Figure 2-4 below. The first stage is pre-design process, which include gathering emerging risks together, select questions and create the first drafts of the survey. The second part which is concerned with developing and designing the questionnaire based on the data and information gathered from the literature review, with this stage progressing through several stages, such as the selection of question types, sequence and order, questionnaire design, clarification of wordings, and modifications and editing—all of which help to achieve the final format. The third phase is validation of the survey through delivering the questionnaire to the experts in the particular research area. This task was to ensure that the survey contents covered the main aim of the research topic and to confirm that all the selected factors will help to answer the research questions. The last part is collection of the quantitative data through using an online survey. The following sections will explain the process and tasks that have been followed to develop the questionnaire in more details.

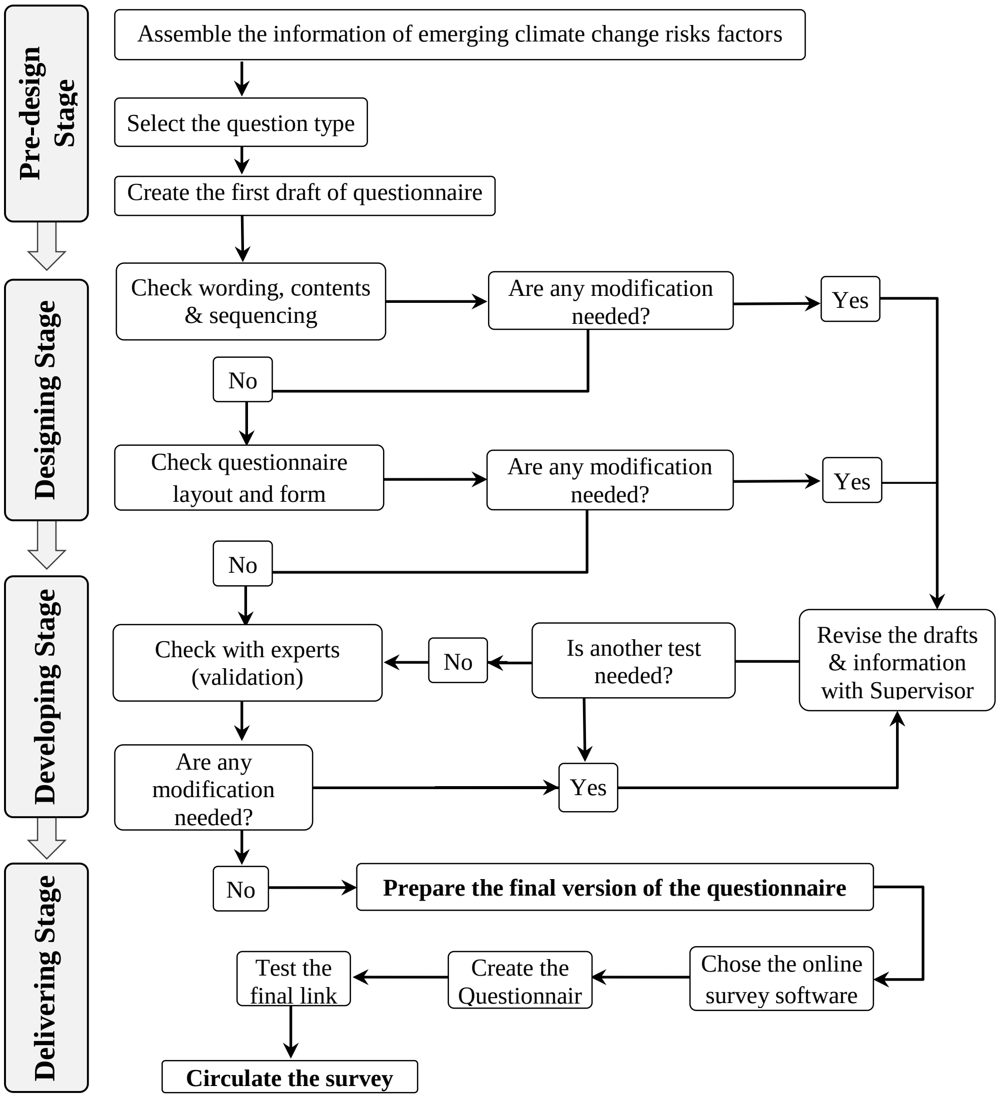

Figure 2-4 Elements of the Questionnaire Design Stages

2.5.4 Questionnaire Structure

The structure of the questionnaire is divided into three main parts: the first part is concerned with the main question, which tests the occurrence and likelihood of 112 factors of emerging risks from climate change scenarios on buildings and real estate based on Likert scale (spanning very unlikely, unlikely, neutral, likely and very likely), whilst also testing the timeframe of these risks (112 risk factors) based on their emerge impacts on buildings and real estate. Table 2.2 illustrates the design of this part. Moreover, the hypothesis used in this part are tow hypothesis; as follows:

- Likelihood Occurrence

Ha_0 ($p > 0.05$): there is no significant difference between respondents in terms of the rating for the likelihood of the occurrence of risks emerging from climate change.

Ha_1 ($p < 0.05$): there is a significant difference between respondents in terms of the rating for the likelihood of the occurrence of risks emerging from climate change.

- Occurrence Time Scale

Hb_0 ($p > 0.05$): there is no significant difference between respondents in terms of the rating for the occurrence timeframe of emerging risks from climate change.

Hb_1 ($p < 0.05$): there is significant difference between respondents in terms of the rating for the occurrence timeframe of emerging risks from climate change.

Q: Which of the following risks do you think will have an impact on your buildings/real estate and in what time frame do you think their impact may emerge*									
*Please check one box from the likely impact and one from the occurrence time frame	**Likelihood impact**					**Occurrence time-frame**			
	Very Unlikely	Unlikely	Neutral	Likely	Very Likely	0-5 Years	5-10 Years	Over 10 Years	Not at all
Emerging risks factor (1)									
Emerging risks factor (2)									
Emerging risks factor (n)									

Table 2.2 Sample of the Main Parts (part one) of the Questionnaire

The second part of the questionnaire asks respondents' opinions in relation to the effectiveness of 24 factors of climate change risk management, as well as whether such risk management strategies are adopted by their organisations or institutions. Table 2.3 provides an example of this part of the questionnaire. Additionally, the main hypothesis used in this section of the questionnaire is as follows:

Hc_0 ($p > 0.05$): there is no significant difference between respondents in terms of the level of effectiveness of climate change risk management factors.

Hc_1 ($p < 0.05$): there is significant difference between respondents in terms of the level of effectiveness of climate change risk management factors.

Q: In your opinion how effective the following climate change risk mitigating strategies. Please also select strategies used by your organisation*						
*Please check one box from the effectiveness of the mitigating strategies and one from the usage of the strategies by your organisation	Very Ineffective	Ineffective	Neutral	Effective	Very Effective	Tick if used by your organisation
CCRM factor (1)						
CCRM factor (2)						
CCRM factor (n)						

Table 2.3 Sample of Part 2 in the Questionnaire

The last section is about the respondents, and includes seven general questions, such as their professional roles, type of organisations or institution, and experiences with the risks of climate change scenarios. The full format of the questionnaire is presented in Appendix (A).

2.5.5 Questionnaire Software

As mentioned earlier, this study project is based on an online survey. Built on this, a software has been selected under certain criteria, such as options, clarity and confidentiality, in an effort to create a good survey—especially for respondents. Amongst a wide range of online programs and software, the questionnaire software that has been chosen is SelectSurvey.NE, which is available on the website of the University of Liverpool.

2.5.6 Sample Size and Collecting Data

In this research project, the online questionnaire survey was circulated electronically through emails. Approximately 473 names of professional roles, such as Risk and Facility Managers, Environment Managers and other experts in this area, employed in Universities, hospitals and housing associations in the United Kingdom, were obtained from the internet throughout their organisations and institutions and by direct emails to the organisations' administrators as well as through experts' consultation. The questionnaire was circulated to all participants personally through via email; however, 133 were excluded for several reasons, such as invalid email address, or not email or contact provided for them. Moreover, the Institute of Healthcare Engineering and Estate Management (IHEEM), which manages and controls public buildings—specifically hospitals and other Healthcare Premises—published the invitation to the survey of this research project on their website, with a monthly electronic newsletter on November 11, 2013, also detailing the survey, as presented in Appendix (B).

Furthermore, the data collection stage through the use of the online survey was carried out to assist other factors in increasing the response rate. This was adopted with the use of personalised email invitations and follow-up reminders; however, after the second circulation reminder emails, a gift voucher was provided for anyone who responded to the survey and completed the entire questionnaire. The reason behind this was to motivate and encourage respondents to complete the entire survey. According to Cook *et al.,* (2000), the target of the response rate should be reached after the third invitation email—but not usually more. It is highly expected that the contact beyond the third reminder email could be considered by many of the participants as intrusive or nuisance, thus encouraging a negative response (Molasso, 2005).

Since the number of risk and Facility Managers, Environment Managers and other experts in this area where unknown, based on a conservative estimate that the emerging risks from climate change will be known to only 5 percent of the professionals (p= 0.05), and for achieving the target of a sampling error of within 5 percent (SE= 0.05) at a confidence level of 95 percent [(1-α) = 0.95; Zα/2 = 1.96], the minimum sample size (*s*) would be (McClave *et al.,* 2005):

$$s = \frac{(Z\alpha/2)^2 p(1-p)}{SE^2} = \frac{1.96^2(0.05)(0.95)}{0.05^2} = 73 \qquad \textit{Equation 2.1}$$

In this study, a total of 165 respondents to the survey responded to at least 10 questions out of 136 questions in the questionnaire with 78 respondents valid and completing the entire survey and this represent 23% as response rate. This percentage has been accepted as it fits within the predetermined sample size. Furthermore, this response rate is expected as average response rate from online survey by many researches and studies such as Prahalad and Hamel, 1990; Akintoye, 2000; Couper, 2000; Mersdorf, 2010.

Furthermore, This response rate to the survey was accepted due to many reasons such as the survey focused on the practitioners of buildings and real estate those who have a direct relationship with the potential risks of climate change scenarios on buildings and real estate, such as facilities managers, risk engineers and managers and real estate's portfolio managers. In addition, the questionnaire consists of a two-field likelihood of the emerging risks of climate change patterns and occurrence time scale of these emerging risks factors.

2.5.7 Data Analysis

This part illustrates the statistical methods adopted for this research project. The statistical analysis presented in this chapter is associated with the objectives and hypothesis of the study. Prior to conducting the analysis, the dataset is firstly checked in terms of codes in order to be ready for analysis. In an effort to guarantee that the data of the study is plausibly accurate and ready for use when conducting the statistical analysis, the screening and cleaning of the data is curtailed in order to perform statistical analysis. Since this research is based on the use of ordinal data using a Likert scale ranging 1–5, minimum and maximum value are used to check whether or not the values lie in this range, with any observations with missing data needing to be removed. During this stage of the research project, all procedures are implemented using SPSS 20 software, along with the use of the Microsoft Excel program for various tasks of analysis. Afterwards, statistical measures were calculated with the SPSS software; the full results and descriptions can be seen in chapters 12, 13 and 14.

2.5.7.1 Weighted Arithmetic Mean

The weighted mean is used to establish how high or low the responses of subjects are in regard to each of the statements (variables) in terms of likelihood impact and occurrence timeframe, taking into the account its benefits in ordering the statements according to the lowest to highest weighted arithmetic mean.

2.5.7.2 Standard Deviation (S.D)

Standard Deviation (SD) is to be used to identify the deviation of responses given by the subjects of the study for each of the statements (variables) in the research project; therefore, it is noted that the standard deviation shows the dispersion in subjects' responses for each emerging risk factor. Thus, the value closest to zero indicates that the response is focused on very close answers of a particular statement, and decreased dispersion between the respondents.

2.5.7.3 Coefficient of Variation (CV)

Coefficient of variation (CV) is one way of interpreting the relative magnitude of the standard deviation (SD), which is concerned with dividing it by the mean. This ranges 0–100%: the closer the value to zero, the lower the dispersion in the responses of a particular statement across subjects. Hence, CV helps to observe that even a lower standard deviation does not mean less dispersion within the data. In this study, CV is to be used so as to order the statements according to the lowest weighted arithmetic mean and lowest standard deviation.

2.5.7.4 Mean Rank

Mean rank is used to rank the emerging risks factors, where the highest mean rank should have a greater number of high scores within it. Similar to the weighted mean, mean rank is adopted in this research project so as to order the statements in line with lowest to highest rank mean.

2.5.7.5 One Way ANOVA F-test

One Way ANOVA F-test was used to test the research hypothesis, as well as to determine the significant statistical differences in the emerging risk factors in terms of their likely impacts and occurrence timescale according to the differences between groups of professional role and types of organisation or institution.

2.5.7.6 Tukey's HSD test

The multiple Comparisons Post Hoc test by Tukey HSD is carried out as a second task when the ANOVA test shows a significant difference in emerging risk factors between groups of interest. It compares all possible pairs of mean of the groups (professional roles and types of organisation); therefore, Tukey's HSD test will enable the analysis to determine which groups of respondents in the sample shows a difference in the statements.

2.5.7.7 Kendall's Coefficients Concordance

Kendall's coefficients concordance is applied in order to examine agreements between the respondents to the survey on the ranking of emerging risk factors of climate change. The value of Kendall's coefficients ranges between 0 and 1, where 0 means perfect agreement whilst 1 means no agreement.

2.6 Summary of this Chapter

This chapter has illustrated and described the research methods implemented in this research project. Moreover, this chapter started by explaining and illustrating the different research methods, such as qualitative, quantitative and mixed-methods, in order to justify the approach applied in this research project, which is a hybrid approach. Furthermore, the design and development of the questionnaire progressed through several stages and tasks, starting with identifying the risks emerging from CC factors, and culminating with the final format of the questionnaire, ready for circulation. The purpose of conducting online survey beside the highlighted advantages of questionnaire is to collect more data across the UK from experts and practitioners in different sectors and organisations (Evans and Mathur, 2005). However, there are other different methods in order to collect data such as interview and fieldwork/site visit (Saunders et al., 2012). These type of approaches i.e. interview, site visit in this study will be difficult to cover all aspects of the study along with preoccupation of professionals in the building sector with their roles and duty as well as the limited time of the researcher.

The questionnaire was delivered to professionals at several organisations and institutions through online means in order to collect data. The collected data in this research project also progressed through several stages and tests with the use of SPSS 20 and Microsoft Excel software. The full results are presented in the following chapters of this study.

CHAPTER 3: CLIMATE CHANGE

3.1 Introduction

In the present, there are many variables that have affected and will continue to affect our daily lives and the future in both negative and positive ways. One of these variables is climate change within our environment—or the so-called phenomenon of global warming, which is the buzzword in environmental thinking; apparently, however, the term is being updated to ‘climate change’. Although many people use these terms interchangeably, there are important differences between the two, as will be discussed later on in this chapter.

Moreover, the differences have caused widespread debate across the globe, with people divided into two groups: one believing that it is a natural phenomenon whilst the other agree with this, indicating that the phenomenon is owing to and further augmented by human activities on the earth.

The argument also considers the future features, and attempts to draw a road map, which helps to predict the nearby and distant future of climate change scenarios and the potential risks across all sectors. This will help to identify solutions and accordingly reduce the distance of experiments so as to avoid the impacts and risks of climate change patterns.

In this chapter, discussion will centre on climate change from a scientific perspective in terms of its concept, causes, scenarios and importance, as well as providing a historical overview.

3.2 Climate Change Concept

3.3 Climate and Weather

In order to understand climate change, the concept of ‘climate’ should be defined. The Oxford English Dictionary (2010) defines climate (noun) as ‘*the normal weather conditions of a particular region’.* In addition, ‘climate change’ may be defined as (mass noun) ‘*the change in global climate patterns apparent from the mid to late 20th century onwards, attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels’* (Stevenson, 2010).

It is clear that the term ‘climate’ is more inclusive than ‘weather’. It is important to recognise the difference between weather and climate in order to ensure understanding of the meaning of climate change in a clear and concise way. Weather is the condition of the atmosphere at a specific time and place (EPA, 2009). In addition, weather is the condition of the environment around us every day, which includes temperature, humidity, prediction of rain, snowfall in the winter and wind speed. Moreover, weather is what can be heard on the news each day, which is subject to change in the short- or long-term: for instance, from hour to hour or from day to day (Department of Ecology, 2012).

On the other hand, however, climate is recognised as the average weather recognised or expected during a long period of time (Met office, 2012). Climate (average weather) described from the average and variability of the recorded weather, including temperature, rains, winds and storms during long periods of time, ranging from months to thousands or millions of years. Climate is also used to describe the condition of the weather as the statistical description of the climate system during a 30-year period, known as the classical climate period (WMO, 2009).

In addition, climate may be described by Department of Ecology (2012) as the average weather over a long period of time for a specific area. Climate describes the outcome of all-weather that occurs over a long period of time in a specific region; this includes the average status of the daily weather, the usual weather of seasons, which are Winter, Spring, Summer and Autumn, and also the average weather for unusual weather events, such as storms, tornadoes and floods. Climate shows how weather is expected to be in the place in which we live. Clearly, recognising and keeping in mind the difference between climate and weather, it can be stated that climate is expectation, such as cool, dry summer and wet winters, whilst weather forecasts the day, such as rain in the morning and afternoon sunshine.

As can be determined from reviewing the definitions highlighted previously, along with the link and differences between climate and weather, it can be seen that weather is the weather condition in a short period of time for a particular place, which includes the weather predictions for in the very near future and the state of the atmosphere. However, the climate refers to the sum total of all-weathers, which occur over a long period of time in a specific area. In addition, this is accompanied by a description of the conditions and changes in the climate for the past periods in order to predict the potential climate patterns in the future; this is known as a climate change, which will be defined below.

3.4 Climate Change and Global Warming

Climate change makes mention to the change in the condition of the climate, which can be identified through the use of statistical tests. These changes include those in the properties of the mean and the variability of the weather, which continues for a long period of time—naturally decades or longer (IPPC, 2007a). Moreover, climate change refers to any prominent changes in the recorded climate lasting for a long period of time; in other words, the Environmental Protection Agency (EPA, 2009) points out that climate change can be defined as the major changes in the quantities of temperature, rainfall, snow, winds and storms patterns, which last for decades or even longer. In addition, climate change means the change in the average condition of the climate and the variability of its properties, which includes patterns of temperature, rains, humidity, wind, storms and seasons. Climate change is not only a change in the weather; it also affects more than this over a long period of time, such as seasonal changes (Department of Ecology, 2012).

The repetition of climate change in the climate system condition over time is due to natural changes or as a result of human activities. Hertin *et al.*, (2003) defines climate change as *'any change in climate over time, whether due to natural variability or as a result of human activity'*. The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as *'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural variability observed over comparable time periods'* (McMullen and Jabbour, 2009).

It is also noteworthy to recognise that climate change and global warming are different but nonetheless are closely related; some people use the terms interchangeably. Global warming may be recognised as the main causes of climate change. Global warming refers to an increase in global temperatures, whilst climate change includes other more specific types of change and pattern. Warmer global temperatures in the atmosphere and oceans contribute to changes in climate, which include rainfall patterns, storms and droughts, humidity and sea level rises. Furthermore, as global warming is planet-wide, the concept can also refer to changes at different levels in the world, such as globally, continentally, regionally and at a local level. Although a warming world is recognised as a global problem, there are many areas in the world that will face different specific changes in their climates; these will have unique risks on the environment in general and specifically on people and buildings (Department of Ecology, 2012).

Global warming is recognised as the rising of average temperatures in the lowest layer of the atmosphere and near to the Earth's surface. Most changes in the patterns of the global climate are caused by increases in temperatures in the earth's atmosphere. Similarly, the phenomenon of global warming, changes in rainfall and sea level rises are considered a part of climate change (EPA, 2009). According to McMullen and Jabbour (2009), global warming can be defined as *'gradual increase, observed or projected, in global surface temperature, referred to as the global temperature, as one of the consequences of the enhanced greenhouse effect, which is induced by anthropogenic emissions of greenhouse gases into the atmosphere'*. In addition, the average surface air temperature of the planet is considered an important index, which spans back to 1860. Importantly, this index is based on the aggregation of millions of thermometer measurements, all taken from different places around the world (Hulme *et al.*, 2002).

It is clear that climate change is a broad term referring to changes in the global environment, including changes in weather, temperatures, sea level, storms, winds and precipitation. According to Environmental Protection Agency (EPA, 2009), in most places in the world, the Earth's climate has changed, meaning the average temperature has risen. Scientists have observed that the beginning of temperature change stems back to the late-1800s. Most of the rises in temperature have occurred rapidly during recent decades. Moreover, the Earth's climate has changed many times over a long period of time; this change can be recognised as a result of responding to natural causes; however, our climate has changed rapidly due to continuous human activities in the composition of the atmosphere and increases in land use, which started in the early-1900s (Met office, 2012).

It is clear that global warming may be considered as one of the causes of climate change. In addition, these changes in climate stem from several different factors, as will be discussed and illustrated later on in this part of research.

3.5 Background of Climate Change

O'Neill *et al*., (2001) cites Callendar (1938), who compiled existing measurements in the 1930s, and points out that various significant build-ups of global warming occurred. Whilst most notions of measurements are insufficient and are not considered reliable, the assumption was made that any emission of carbon, as a result of human activities, would be absorbed by oceans, which has a considerably large capacity to deposit carbon. In the late-1970s, the atmospheric sciences community started to prepare reports relating to the possibility of overheating the global climate due to increased emission gases pollutants being released into the atmosphere due to natural factors or increasing human activity (Changnon, 1995). Moreover, it is noted that most of the very significant increases in the average global temperatures were initiated from the mid-20th Century, which achieves much consensus. This refers to the observed increase in Greenhouse Gases (GHG) due to increases in human activities. Over the past 50 years, human activities are recognised as significant causes of the global warming average over each continent, except Antarctica. During this period, the assumption has been made that cooler temperatures, rather than warmer ones, would be as a result of the compensation effect of both volcanic eruption and natural variation in solar radiation (UNEP, 2009).

Essentially, climate change started in the ancient past before human activity began to change the world, and in this vein, it can be stated that climate change occurred prior to the existence of human beings (Woodward, 2008). Based on the work of Arrhenius (1896), as cited in O'Neill *et al*., (2001), climate change is a new phenomenon as a global problem at the present; however, scientists have considered this to be a problem for more than a century. In 1827, the French mathematician Jean Baptiste Fourier launched the name 'greenhouse' after he compared the atmosphere to the glass walls of a greenhouse. After several decades, the British physicist John Tyndall identified the main gases involved in the greenhouse; he also voiced the expectation that the changes in these gases' concentration and density could help to uncover the truth about the secret of changes in the climate. The alterations in the current climate were potentially associated to the increase of the CO_2 level as a result of increases in combustion of coal. This fact was adopted first by the Swedish chemist Svante Arrhenius.

In the first years of the 20th Century, the world began to pay attention to the phenomenon of global warming due to the number of scientists believing that the main reason for this phenomenon was the accumulation of carbon dioxide (CO_2) in the atmosphere (O'Neill *et al*., 2001). Furthermore, the first note of climate change—specifically global warming—was at the end of the 1950s, at which point temperature was measured by weather balloons. It was noted that, in the lowest 8 kilometres of the atmosphere, the temperature increased by 0.1^{o}C on average per decade (Houghton *et al.*, 2001).

Clearly, climate change is not a new phenomenon: as recognised, it started before humans existed. Nevertheless, the largest changes in the climate are occurring at the present time, mainly due to human activities. However, the GHG that existed prior to human existence stemmed from natural factors, including volcanoes, earthquakes and the movement of the earth around the sun; these were the key causes of climate change. Recently, however, climate change has been regaining considerable attention as an international issue due to the noticeable changes in the environmental climate and the risks associated with such change. The following section will focus on the main causes of climate change in an effort to understand the potential scenarios of climate change.

3.6 Causes of Climate Change

The obvious changes in the global climate are based on both natural and human causes, such as interactions between its components and human causes, which include increasing activity. The Earth's climate change is a natural phenomenon, stemming from several natural factors, including interactions between oceans and the atmosphere, gases from volcanic eruptions and also changes in the Earth's orbit around the sun, which has a notable impact on energy imported from the sun (Hulme *et al.*, 2002); therefore, it is clear that climate change can result from three factors, as illustrated below and as highlighted by EPA (2009):

- Natural factors, such as changes in the orbit of the Earth around the sun, as well as the sun's intensity.
- Natural processes within the climate system, such as the interaction between oceans and the atmosphere, and the quantities of gas emissions from volcanic eruptions.
- Human activities, which can be further divided into two groups:
    - Those helping change the climate in the atmosphere, such as burning fossil fuels and increasing the emissions of greenhouse gases.
    - Increasing the use of the land's surface, such as cutting down forests, and developing cities and suburbs by building roads and infrastructure.

Notably, the causes of climate change have stemmed from a combination of both natural factors and human activities. The main causes will be described below, including both natural causes and human activities.

3.6.1 Earth's Orbit and Sun's Intensity

The regular changes in the Earth's climate are due to the change of the Earth's orbit around the sun. This is known as Milankovitch cycles, so-called after the Serbian mathematician responsible for their calculation. (Woodward, 2008).

In addition, the Earth rotates around on its axis every 24 hours, thus causing night and day. This axis tilts almost 23.50 from vertical, causing summers and winters. Consequently, the sunlight reaching the Earth's surface changes from one region to another, which affects the global air circulation in the atmosphere (ibid).

3.6.2 Volcanic Activity

Volcanic activity is considered to be one of the natural processes causing climate change scenarios. In actual fact, volcanic eruptions affect the cooling of the atmosphere due to spray emanating from volcanos' emissions, such as sulphate, organic and black carbon, nitrate and dust. This spray prevents the sun's rays from reaching the Earth's surface as it absorbs some of these rays and reflects the rest back to space (UNEP, 2012). Furthermore, strong volcanoes eruption can send large amounts of sulphur gases into the stratosphere, which are then converted to sulphate aerosols; these stay there for a long time. Stratospheric aerosols disperse globally due to the slow combination between stratosphere and troposphere where the aerosols are removed from the atmosphere. Because of this, the aerosols reflect the sun's rays and the climate becomes colder (Minnis *et al*., 1993).

It is noted that the gases emitted from volcanoes have a large impact in terms of the cooling or heating of the atmosphere, although such changes depend on the duration of its stay in the upper atmosphere and its proximity to the surface of the earth, as discussed above. Volcano eruptions impact climate change in the short-term and help to change the natural climate of the Earth.

3.6.3 Greenhouse Gas (GHG) Effect

According to Intergovernmental Panel on Climate Change (IPCC, 2007a), the Kyoto Protocol—notably the first International agreement interested in and focused on climate change—has placed emphasis on reducing the greenhouse gases emissions from developed countries in an effort to reduce its effects on climate change in the world. The most important greenhouse gases have been considered in this protocol, based on the most influential on climate change.

Furthermore, the Environmental Protection Agency indicates that some greenhouse gases are produced naturally, such as water vapour (H_2O) and carbon dioxide (CO_2); however, it remains that human activities, including the burning of fossil fuels, contribute to increasing the concentration of these gases in the atmosphere and further increases in their effectiveness to change the climate as a result. In addition, the growth of greenhouse gas emissions were monitored during the period spanning 1970–2004, after which it was concluded that the greenhouse gas emissions started before the initiation of the industry era, but increased by approximately 70% due to human activity. Figure 3-1 below described this growth (IPCC, 2007b). Moreover, during this same period, the transportation, industry and energy suppliers emitted large amounts of the greenhouse gases, whilst other factors, such as buildings, agriculture and the cutting down of forests, are all seen to create a low rate of greenhouse gas emissions (IPCC, 2007a).

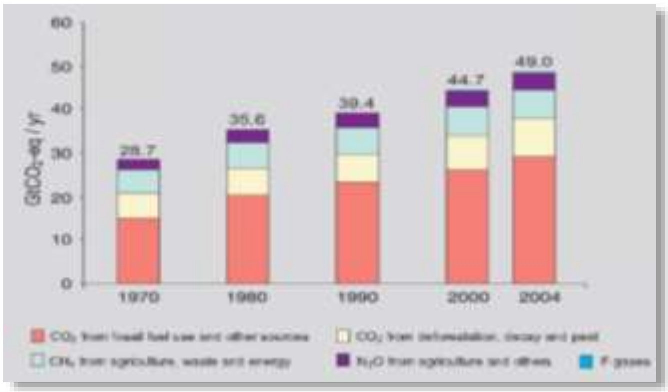

Figure 3-1 Global Annual Emissions of Anthropogenic GHGs; Source: IPCC, 2007b.

In addition, Karl and Trenberth (2003), stated that the changes in global atmosphere is due to the activity of greenhouse gases in the atmosphere for up to more than a decade, which led to the increases in its accumulation and concentration in the atmosphere. These gases are distributed all over the atmosphere across the world. It has been observed that there has been an increase in carbon dioxide by 30% since pre-industrial times, and in particular, most of this growth has occurred since 1965, rising from 280 parts per million by volume (PPMV) to 370 (PPMV) in the present era. More specifically, over the past 30 years, the temperatures has gone up at an increased rate, where the relationship between temperature and carbon dioxide (CO_2) is found to be between 1901 and 2000, with the increasing temperature following the concentration of CO_2, as shown in Figure 3-2 (EPA, 2010).

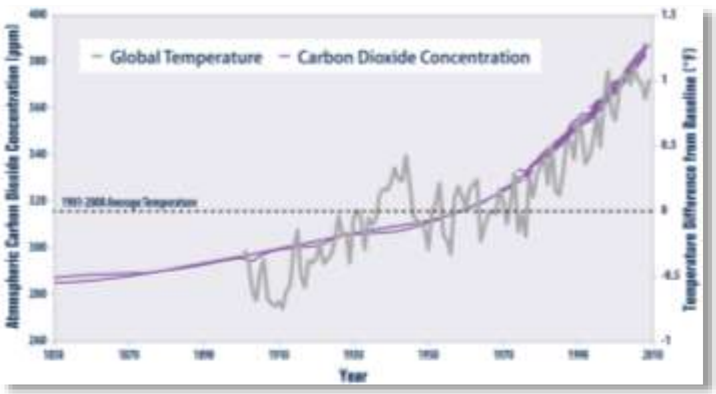

Figure 3-2 The Link Between Greenhouse Gases and Temperature from 1850 to 2009; Source: NOAA, 2010.

With the aforementioned information taken into account, the greenhouse gases are recognised as directly linked to climate change, which is seen to play a key role in changing the atmosphere temperature over time. These gases have been identified as present in the upper atmosphere before humans existed, and they show interventions in the composition of various climate phenomena, such as clouds, rain and winds. However, in the present time, the current density of these gases has increased significantly due to human activities, following the start of the industrial and technology era. This will be discussed in the next part of this chapter.

3.6.4 Human Activity

According to EPA (2010), human activities, including the burning of fossil fuels, industrial activities, deforestation and using land to create a built environment, are the key causes of climate change, witnessed by increases in the density of greenhouse gases in the atmosphere.

Moreover, the United Nations Environment Programme (UNEP, 2009) indicates that, after comparing the effects of various natural factors and human activities on climate change, scientists conclude that human activities are more responsible for climate change. In the start of the second half of the 20th Century, human activities contributed to increased temperatures, and changes in wind patterns and sea levels. Human activities have caused warming over the last three decades, and have had a discernible global influence on the changes observed in many physical and biological systems (ibid). The average temperatures have increased by approximately 0.8^{o} C (1.4^{o} F), measured at the land's surface, during the last century. However, average global temperatures have risen by 4^{o}C (7^{o} F) during the past 200 centuries, thus meaning that there is a dramatic increase in the global rate of temperature. This also demonstrates that the rise in global temperature will continue to the present age—especially after the exciting entry into the industry and technology era—which depends on the consumption of large amounts of energy, notably taken from the burning of fuel; therefore, the concentration of carbon dioxide increases in the atmosphere (Woodward, 2008).

In addition, at the present time, human activities are seen to influence the global climate through the emission of approximately 6.5 billion tonnes of carbon dioxide (CO_2) into the atmosphere each year, most of which come from the urgent need for energy by burning fuel, oil and gas. Excessive land used to develop cities and build roads has further contributed to the annual emissions by an average rate of approximately 1.5 billion of carbon (Hulme *et al.*, 2002).

According to Karl and Trenberth (2003), there is no longer doubt that human activities are changing the atmosphere, and greenhouse gases from these activities are considered to be notably influential on climate change.

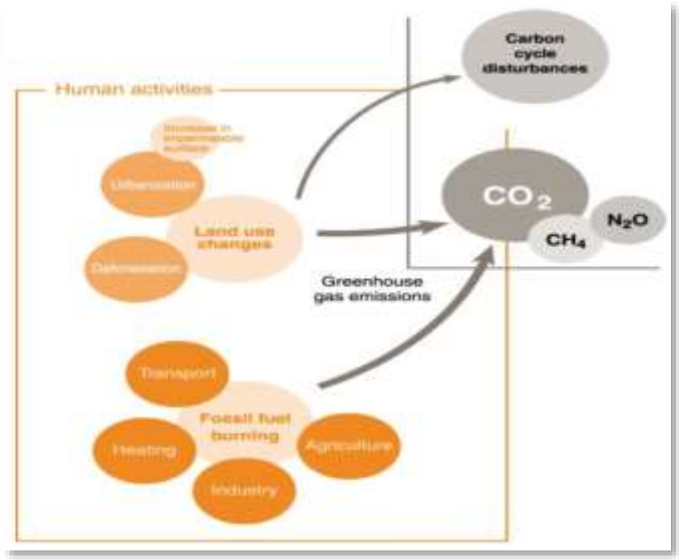

Figure 3-3 The Relationship Between Human Activities Greenhouse Gases; Source: (UNEP, 2009)

As can be seen from the Figure 3-3 above, taking into account the previous information, human activities have resulted in increases of greenhouse gases. These are divided into two groups:

- The search for energy by burning fossil fuel, oil and gas for use in agriculture, industry, transport, and heating and cooling the air.
- Developing and changing lands, including cutting down forests, urbanisation, increased use of impermeable surfaces, and developing land for farms, cities and roads.

Most of these activities contribute to climate change by increasing the emissions of Carbon dioxide (CO_2), Methane (CH_4) and Nitrous oxide (N_2O), which are considered to be the most important of the greenhouse gases; therefore, it can be stated that the main control of pace and magnitude of climate change scenarios is the amount of human activity; however, there are arguments surrounding this statement and the reality of climate change. Accordingly, the following section illustrates the views relating to climate change.

3.7 Different Views on Climate Change

There is extensive debate concerning the main causes of climate change. As noted in the previous sections, scientists and climate researchers are divided into two groups: one group states that climate change stems from natural factors, which they consider to be the main causes of CCS; on the other hand, the second group state that climate change was initiated before human existence by natural factors, but has increased as a result of human activity following the beginning of the industrial and technological era. Importantly, these are the main causes of climate change, which further increase its impacts and risks. In contrast, there are other views relating to the presence of climate change, which state that there are no changes in the climate, with the further view posited that, if found, such changes would not be significant and are not causes for concern because they are both natural and insignificant. This latter group suggests that there is no need to invest large funds into carrying out studies, and warns against so doing. This difference in perspectives is discussed below.

3.7.1 Against Climate Change

According to Burnett (2001), based on the National Academy of Sciences (NAS), at the present time, it is difficult to establish the size and degree of climate change, and its direction is unknown. As a result of this, confidence is limited concerning any actions or studies taken to avoid these changes in the climate—or even merely to reduce the potential risks on the environment. In addition, it is difficult to predict the future of the Earth in terms of global temperature, i.e. will it be warmer or colder than it is now? Will these changes in temperature be induced by human activity?

Based on the global warming conference held in New York in 2008, which discussed the Manhattan Declaration on Climate Change, the conclusion drawn highlighted the following points:

- The emissions of carbon dioxide (CO_2) from human activity are not pollutant and do not cause climate change, which always changes.
- Climate change is still under discussion between scientists, who have not yet reached a unanimous agreement on the issue.
- Increases in global temperature are better than lower temperatures in the context of ensuring life on Earth.
- There is no evidence to suggest that the increase of carbon dioxide (CO_2) intensity in the past has contributed to climate change in the present and will continue into the future.

According to the National Centre for Atmospheric Research (NCAR), the difference in the average global temperature cannot be measured. The signatories of the Kyoto agreement agreed to reduce their carbon dioxide (CO_2) emissions to be between 0.07^{o}C and 0.19^{o}C, which are very small differences. Importantly, the Kyoto agreement does not include developing countries in the reduction of greenhouse gases; positive results will not be garnered when considering that the agreement is restricted to developed countries whilst developing countries emit approximately 50% of all greenhouse gases. Furthermore, in the future, the emissions of carbon dioxide (CO_2) will increase by up to approximately 85% in developing countries, according to the International Energy Agency (Burnett, 2001).

According to Helmer (2007), in reviewing Horner's book, today the temperature of the world is seen to be lower than it was in the Mediaeval period, and at the end of the last Ice Age the rise in sea level was very slight. Importantly, only 3% of carbon dioxide (CO_2) emissions come from human activities, and scientists have not yet reached a consensus on the relationship between these emissions and climate change. Moreover, scientists have demanded sacrifices, such as stopping industrial and technological progress in an effort to reduce the consumption of energy, which will in turn result in reductions of the average global temperature by 0.02°C in 2050 and no more than 0.2°C in 2100. However, this will not happen until the Kyoto protocol is implemented across the globe.

In short, there is no clear rejection of the emergence of climate change events as these views represent only objections to the results of researches and studies related to climate change, especially studies related to the slight change in average temperatures, which are not need a concern in some people’s views. In contrast, however, there is a lack of conviction relating to the Kyoto protocol, which aims to reduce greenhouse gas emissions, which is the main cause of climate change. Opponents believe that this agreement is not feasible in the case of adoption by developed countries.

However, there are other opinions contrary to these views in terms of climate change, and the emergence of its risks at all levels. This is what will be reviewed in the next part of this chapter.

3.7.2 With the Emergence of Climate Change

Climate change is recognised across the world as a global issue for the next millennium (Fortner *et al.*, 2000). According to the latest IPCC reports, there is agreement between scientists indicated that the climate has changed due to increased human activity, and that these activities increase the overall density of gas, which makes up the atmosphere (Oreskes, 2004). According to McCarthy *et al.*, (2001), the increase in the concentration of greenhouse gases over the past 50 years is the main cause of increased atmosphere temperature. In the present time, climate change is a global issue and is the most dangerous issue affecting people and the environment. Moreover, it is also considered a real challenge necessitating rapid intervention (King, 2004). There is no disagreement concerning the reality of climate change around us; however, the argument is concerned with what should be done in regard to this change in climate (Oreskes, 2004). In actual fact, some of the climate changes have resulted naturally from its cycles and the disturbance of the atmosphere climate; nonetheless, during the past century, human activity has helped to increase the mean temperature of the earth on a global scale. Moreover, King (2004) points out that claims suggesting that reducing the emissions of GHGs will damage the economy are merely a myth and are far from reality. In contrast, by reducing these emissions, new economic opportunities and improved living standards will be achieved (ibid).

According to Bostrom *et al.* (2012), as established through the completion of an international survey, there has been some consensus between the economy and business students that climate change is currently considered a real threat to humanity, which could cause food shortages and increased poverty across the world. Furthermore, it is widely accepted that addressing the climate change, along with a reduction in gravity, will require difficult political, economic and social choices. Importantly, however, it cannot be denied that climate change has garnered acceptance as a result of public awareness across the world, with the effects on the future now understood (Lorenzoni and Pidgeon, 2006).

According to the House of Lords in the UK (HL, 2005), cited Rt Hon (2005), climate change is considered an issue for the ministries concerned with the environment and energy, but it has also become an important issue for the Finance and Economy ministries. In this vein, Figure 3-4 represents the international consensus on the fact and reality of climate change, as well as the concern surrounding the seriousness risks of climate change. Moreover, based on a poll carried out by YouGov, around 70% of all UK residents are concerned about the risks and threats of climate change (BBC News, 2005). Furthermore, Table 3.1 below presents some of the studies and research carried out to measure public awareness concerning climate change in the United Kingdom (Anable *et al*., 2006).

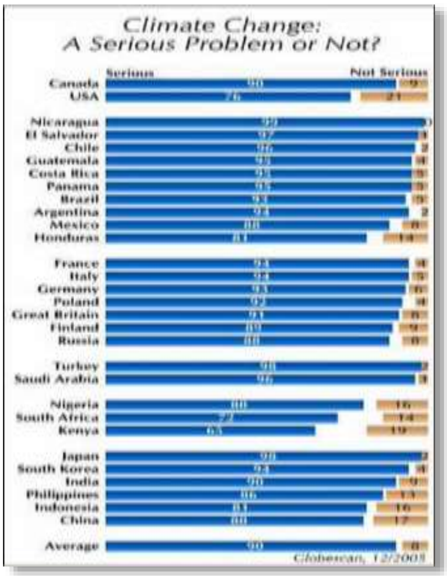

Figure 3-4 The International Concern About the Risks of CC; Source: WPO.org (2006).

Another example is given by Patchen (2006), who claims that people in the US agree about global warming, with around 41% of all Americans believing that human activity is playing a vital role in climate change. In addition, there are further studies and researches that confirmed the reality and emergence of climate change and its impacts, such as those by Schulte (2008), Lorenzoni and Pidgeon (2006), Anable *et al.*, (2006), Oreskes (2005) and Norton and Leaman (2004).

Reference	Title of Study	Date	Data Sample	Agreeing	Disagreeing
(DEFRA, 2002)	Survey of Public Attitudes to Quality of Life and to the Environment	2001	3736 (England)	85%	13%
(Scottish Executive, 2002)	Public attitudes to the environment in Scotland	2002	4,119 (Scotland)	89%	5%
Bibbings and Welsh Consumer Council-WCC, 2004)	Climate Concern: Attitudes to climate change and windfarms in Wales	2004	988 (Wales)	84%	3%
(BBC / ICM, 2004)	Climate Change Poll	2004	1007 (UK)	-	4%
(Poortinga *et al.*, 2006)	Climate Change and Energy Options Public Perceptions of Nuclear Power	2005	1491 (England)	91%	4%

Table 3.1 Some Studies about the Reality of Climate Change In the UK; Adapted from Anable *et al.*, (2006)

It can be seen that climate change is a fact, and has become a globally recognised problem that needs to be faced and dealt with, and its gravity reduced. Facing this issue through decreasing GHG emissions will be achieved through the union of all countries as climate change will not be affected by only one state. The effects of climate change can be recognised around us, and we still face other risks that may be greater and bigger than before. Fundamentally, it is clear that both scientists and observers of climate have a lot of evidence supporting climate change globally, based on studies and proof registered for long periods of time. Such proof includes temperature records, measurements of rain and wind, differences in sea levels, as well as climate disturbances, such as storms, floods, earthquakes and volcanoes. In addition, in case one or more of these climate change patterns occurs suddenly and without prior warning, or otherwise was not expected of the future climate, this illustrates disorder in the climate system, causing the occurrence of such disasters. This is known as a climate change scenarios (CCS), which will presented in the next part of this chapter.

3.8 Scenarios of Climate Change

3.8.1 Definition of Scenario

A scenario can be defined as *'a coherent, internally consistent, and plausible description of a possible future state of the world'* (McCarthy *et al.*, 2001). Furthermore, climate scenario is known as *'a plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships'* (IPCC, 2007b).

It is important to establish the future scenarios of climate change in order to adapt and mitigate or otherwise to avoid the potential risks of climate change on the environment. According to McCarthy *et al.*, (2001), climate change scenarios are usually required in climate change impact assessments to deliver substitute views of future conditions of climate change scenarios. Moreover, climate change scenarios are used as a base for future climate change effects; these require additional information about the condition of the current climate. Climate change scenarios are known as the differences between the current climate and climate scenarios (IPCC, 2007a).

In the context of this research, the term 'climate change scenarios' will be used to refer to the future of all possible and expected patterns of climate change, which will have significant risks on the building sector. The next section will illustrate climate change scenarios in order to build an essential foundation for identifying the risks emerging from CCS on buildings and real estate in the building sector.

3.8.2 Climate Change Scenarios

Climate change scenarios are essential in order to analyse and assess the potential risks from these climatic patterns (De Wilde and Coley, 2012). According to Alkhaled *et al.* (2007), the potential risks associated with climate change are based on a number of possible climate change patterns (CCP); these scenarios play a pivotal role for decision makers to establish the possible risks emerging from climate change, as well as when adopting suitable polices and strategies. Moreover, the climate change scenarios are different based on the magnitude and strength of their causes. Importantly, these changes could also be in large or small amounts. Climate change scenarios (CCS) are as follows:

- Increasing temperatures.
- Rising sea level.
- Precipitation patterns changing.
- Flooding.
- Extreme climate events including storms and extreme winds.

The main climate change scenarios will be discussed in more detail below.

3.8.2.1 Changes in the Temperature

Climate records illustrate that global warming is occurring more quickly than in the past, where recorded average temperatures in the last century were seen to rise by 0.7^{o}C approximately ten times faster than the average ice age (NASA, 2012). According to the Department of National Oceanic and Atmospheric Administration (NOAA, 2007), recordings of the global temperature have increased by approximately 0.6^{o}C (1.3^{o}F) over the past century, as illustrated in Figure 3-5 that shows the increases in the average temperature.

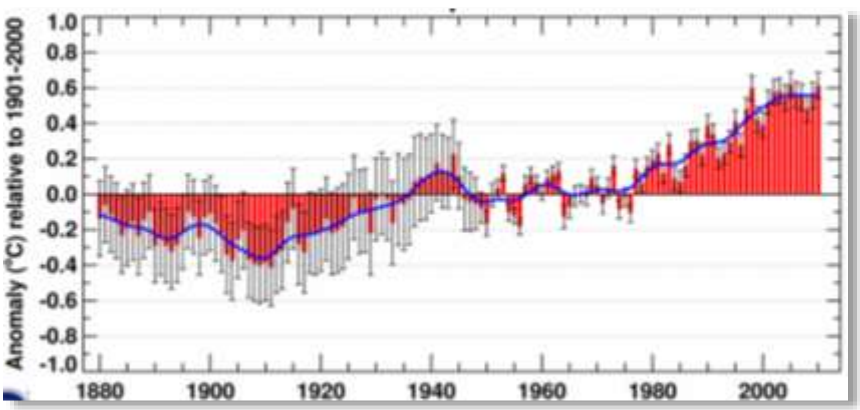

Figure 3-5 Annual Global Surface Temperature Average for the Period 1880-2007. Source: (NOAA, 2007)

Moreover, since 2001, the warmest years have been witnessed throughout the past 30 years, with increases in the average temperatures around three times more than over 100 years ago across the world.

According to Houghton (2001), the warmest decade in the world was the 1990s; the warmest year in the temperature record was 1998.

Temperature varies around the world based on seasons, whilst most areas will reach higher temperatures in winter than in summer; therefore, although daily weather brings about different temperatures across the world, projections indicate that average temperatures in the global climate will reach about 14°C (Met Office, 2012). For example, the World Meteorological Organisation (WMO, 2013) declares that the year 2013 is recognised as the seventh warmest year in the list of temperatures recorded since 1850 (Guardian, 2013). In addition, in the UK, the 2013 winter was predicted as being the coldest temperature recorded in sixty years (Rao, 2013). In consideration to the future of the Earth's temperature, the IPCC team expect that the average global temperature will increase by approximately 1.1–6.4°C (2-11.5°F) at the end of 21st century, as shown in Figure 3-6 below. Furthermore, the average temperature over each continent will grow to be double that of the 20th Century (Pachauri and Reisinger, 2007).

This growth in average temperature will not be evenly distributed over the world; land areas will be hotter than oceans due to the ability of water to absorb and store heat. Projections indicate that the average temperature in most of the north, central and south of America, Africa, Europe and North and Central Asia will be more than the world temperature average; in south Asia, Australia, New Zealand and southern south America, however, the rising temperatures will be close to the global temperature average (ibid).

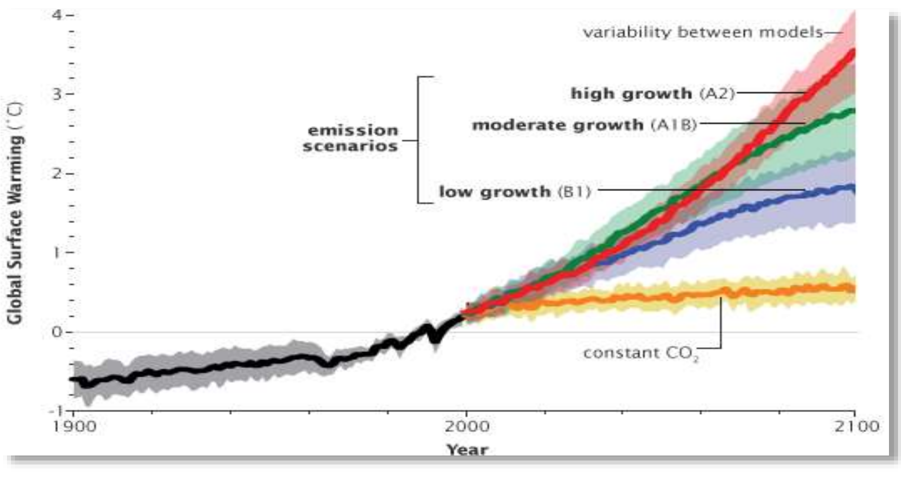

Figure 3-6 The Global Surface Warming in the Future; Source: (NASA, 2012)

3.8.2.2 Sea Level Rise

The highest growth in sea level rises occurred during the last 100 years, at an approximate rate of 1.7 mm each year, which is considered to be the largest rate spanning several of decades, as shown in Figure 3-7 below (NOAA, 2007).

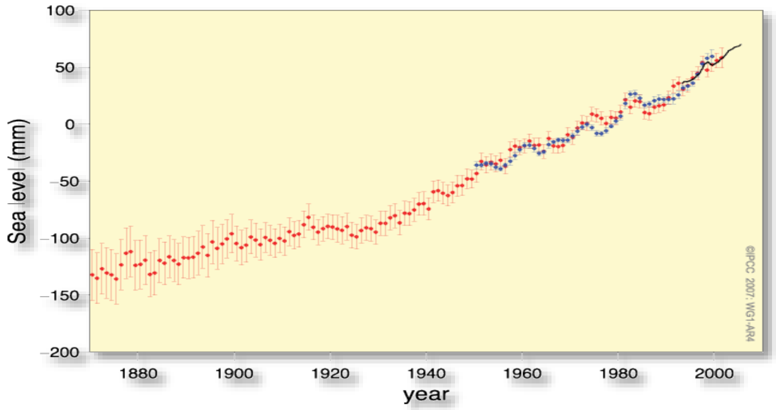

Figure 3-7 The Annual Averages of Sae Level Rise; Source: (NOAA, 2007)

During the 20th century—and based on data from tide gauge—the rate of sea level rise is recognised as being in the range of between 1.0 mm and 2.0 mm per year, meaning the average rise is approximately 1.5 mm each year. This average rate of sea level increase is larger than in the 19th century. Moreover, this rate of sea level rise has grown to ten times what witnessed in the past 3,000 years, according to geological data, as during this period levels ranged from between 0.1 mm and 0.2 mm per year (Houghton, 2001).

In addition, the melting of polar ice sheets and glaciers—notably those that accumulated due to increases in precipitation (all of which occur due to global warming)—is considered to be the main cause of sea level rises, whilst the IPCC expects that the sea level will continue to rise by approximately 15 cm and 60 cm over the course of the 21st century (EPA, 2009). According to the IPCC (2007a), the mean sea level rise during the period 1961–2003 was approximately 1.8 mm, achieving an average of 1.3 mm–2.3 mm per year, scoring the highest rate from during 1993 and 2003. The National Oceanic and Atmospheric Administration (NOAA, 2007) declared that the expected average sea level rise during the 20th century was approximately 17 cm, which is larger than it was in the 19th century; therefore, it is very likely that the rise in sea level will continue due to the melting of glaciers and ice sheets, as well as the increase in the amount of precipitation. Furthermore, it is highly expected that the average sea level rise will increase in the range of 9 cm–88 cm during the period 1990–2100, on a global scale, owing to thermal expansion and the melting of large parts of glaciers and ice cover (Houghton, 2001).

It is clear that sea level rises will continue based on the causes of climate change, such as greenhouse gases and their extent, and there is no accurate expectation for its future. It could be stated that sea level rises work in a cycle with ice sheets, glaciers and rainfall, affecting in more climate change patterns, such as flooding.

3.8.2.3 Differences in Precipitation

The increasing temperature of the Earth's surface will make more water available in the occurrence of storms due to evaporation. As a result, some areas exposed to these storms will experience a significant increase in rainfall and a greater risk of flooding, whilst areas remote from these storms will be hit by drought due to a lack of precipitation (EPA, 2009). Moreover, the average precipitation globally has been seen to increase in most parts of the world in the late-19th century and throughout the first half of the 20th century, as shown in the Figure 3.11 below. Increases in rainfall occurred in the high latitudes in the northern and southern hemispheres. There was also a lack of rainfall and the risk of drought in the region of tropical Africa and southern Asia (NOAA, 2007). It is projected that such precipitation will increase in tropical and high-latitude areas, which are due to experience increases in mean rainfall. Even in the subtropics, located in the mid-latitudes, there has been a lack of rainfall. An increased rate of rainfall shows a convergence in a period of precipitation. In addition, it is expected that the mid-continental areas will be exposed to extreme drought during the summer periods (WMO, 2009).

Clearly, the average rainfall is raising, as presented in Figure 3-8, and is expected to result in floods along with sea level rises. This indicates that, if flooding occurs, it will be more severe and harmful across many sectors and levels in the environment.

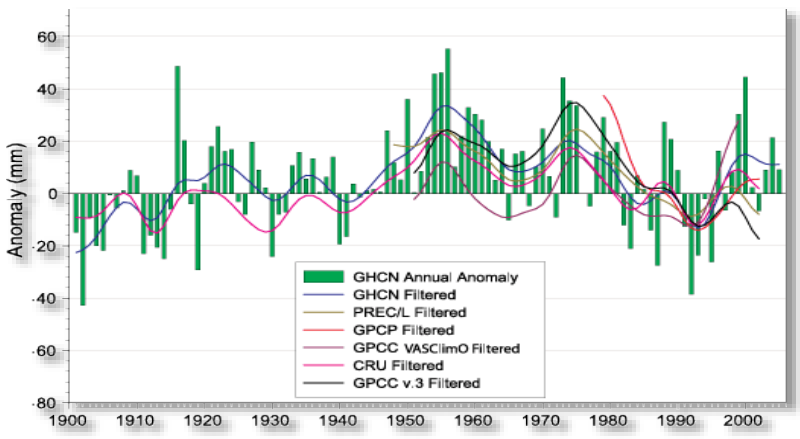

Figure 3-8 The Annual Land Global Precipitation; Source: (NOAA, 2007)

3.8.2.4 Extreme Weather Events

Extreme weather events include unusual climate patterns, such as hurricanes, extreme rainfall, storms, subsidence, flooding, drought and heat waves (Hallett, 2013).

Due to high temperatures in the climate and on the sea's surface, which help in the revitalisation of hurricanes, it is likely in the future that hurricanes will be stronger and have greater influence on the environment (EPA, 2009). Since 1970, in the Atlantic, hurricane activity has increased in volume, reaching its peak in 2005 (NOAA, 2007). Furthermore, during recent years, the total number of hurricanes has broadly remained the same, although it has increased in the frequency of strong hurricanes, with warmer temperatures globally. During this period, there has also been intense precipitation (Cowie, 2007). According to Pachauri and Reisinger (2007), extreme climate change events, such as heat waves, storms and flooding, are increasingly prevalent and likely to occur in greater intensity in future, as in the last 50 years. It has become widely recognised that the extreme events of climate change, including heat waves, heavy precipitation, severe Winters, and storms, may increase globally over most land areas (Cheng *et al*., 2012). Subsequently, it is widely expected that extreme climatic events will have adverse risks and induce much damage on several levels of the environment, including human systems, such as the built environment (Pachauri and Reisinger, 2007).

With the aforementioned information taken into account, it is clear that climate change scenarios do not depend on expectations or on the predictions of the state of the future climate, but rather rely on studies and past experience. Therefore, the outlook of the potential patterns of climate change depend on the previous records and results. The climate change scenarios are interconnected strongly, whilst the occurrence of one of them will result in the severity of another or may even assist in its emergence. For example, rainfall and sea level rises will lead to flooding. In addition, in the present, with the increase in the causes of climate change scenarios, the global climate will outface strong waves of change in climatic patterns, such as hurricanes, flooding and extreme storms. It is even likely to face a mixture of these climatology scenarios, which might occur in one place at the same time where it was unlikely to be in the distant past.

On the whole, CCS play a vital role in adversely affecting the environment in different aspects, such as across the built environment. The following part of this chapter will focus on the correlation between the building sector and climate change scenarios; this will be the cornerstone of the study in terms of identifying the risks emerging from CCS on buildings and real estate.

3.9 The Relationship Between Climate Change Scenarios and the Building Sector

According to the Environmental Justice Foundation (2012), climate change will intensify stresses and will increase its impacts on existing social, environment and economic domains. Moreover, in the 21st century, people have come to face climate change, which is recognised as one of the main challenges affecting lives in specific areas, such as health and wellbeing, the environment and the economy (De Wilde and Coley, 2012). The risks of climate change are considered to be the most prevalent of issues affecting the social domain, the natural environment and the human system, with risks and damages inflicted upon the built environment (Garvin *et al*., 1998). Furthermore, the risks of climate change scenarios will threaten many sectors of the environment around the world; however, the unique aspects, which are more likely to be under the threat of the impacts and risks of climate change patterns, are physical, biological (environment), humanity and economic (McCarthy *et al*., 2001). According to Midgley *et al.*, (2005), the projected risks of climate change have serious implications in regard to the competing interests of environmental integrity and socio-economic development.

In general, climate change is a global issue without boundaries, and its potential risks and effects will reach each sector across society (Brown *et al*., 2011). One of these sectors is the built environment, whilst the risks of climate change occurring in this sector will affect other sectors in many ways. The built environment refers to the environment surrounding humanity, which is considered a result of human activity, including buildings, neighbourhoods and cities with infrastructure. It is often considered at an individual building level (Capon and Oakley, 2012). Buildings normally have a lifetime of 100 years; however, existing buildings are designed for a specific climate condition in a specific area. Accordingly, the existing buildings and real estate required to be adapted need to cater to a wide range of expected climate change conditions; however, as the climatic data used in the building sector is only 30 years old, this would result in exacerbating the risks of climate change scenarios on buildings and real estate (Pretlove and Oreszczyn, 1998). Usually, building performance measurement depends on the climate exposed whilst the age of the buildings varies from between 50 and 100 years or more (De Wilde and Coley, 2012). Moreover, most of the buildings and real estate are designed to last several decades of time and longer, meaning it is therefore crucial to consider the impacts and risks from climate change, particularly on property, so as to ensure the longevity of such buildings (Hacker *et al.*, 2005).

Correspondingly, the building sector contributes significantly to greenhouse gas emissions by using operational energy for construction and demolition (De Wilde and Coley, 2012). Basically, the massive growth in construction buildings and real estate contributes approximately 30% of the global average of GHGs emissions, whilst consuming approximately 40% of all energy resources. This contribution percent from the building sector in GHGs emissions might increase to double in the next 20 years due to the tremendous growth in construction around the entire world (Lemmet, 2009). In other words, energy is important for buildings as they are used for heating or cooling, lighting and other energy services; hence, it will continue to contribute in terms of increasing greenhouse gases emissions (Garvin *et al*., 1998).

However, fundamentally, climate change has large impacts and can inflict damages upon buildings and real estate through extreme climate change events, such as higher temperature, storms and rainfall (Steenbergen *et al*., 2012). The extreme weather events, such as strong storms and flooding, combined with long-term gradual change in the climate, impose direct risks upon the building sector. The most challenges facing buildings and real estate arise from increasing average temperatures and changing precipitation patterns (Capon and Oakley, 2012).

According to Capon and Oakley (2012), in the building sector, existing premises were designed and built whilst taking into consideration the climate conditions at the time of construction. As a result of this, buildings and real estate are not necessarily able to withstand the effects of climate change scenarios or to deal with their potential risks. It is imperative to understand the impacts and risks of climate change patterns on existing property before adopted any action against such emerging risks. Furthermore, buildings should be designed and built to reach the minimum of resistance to different circumstances, which determined by the effects of climate change, as these changes in climate affect the existing and newly built buildings (Steenbergen *et al*., 2012). Additionally, climate change affects the environment on both levels—regional and local level. Figure 3-9 below illustrates these impacts, which are based on the changes of the climate, from minor changes that occur over time, such as increasing the average temperature, through to extreme weather, such as flooding and storms. Buildings' positions and their environment are all impacted by climate change, leading to inducing impacts on the behaviour and performance of the buildings, such as through failures in the electrical grid caused by overloading or other problems (De Wilde and Coley, 2012). According to Garvin *et al.* (1998), climatic change scenarios will impose several risks upon the building sector, which will impact buildings and real estate in many areas, as follows:

- Damaging in construction process includes problems with material use, soil conditions on site, site flooding and days lost due to climate condition.
- Damaging in property's fabric including storm damage, foundation structure problems, corrosion of metals, flood damage and water penetration problems.
- Damaging in internal environment of buildings and real estate this include energy consumption, temperatures conditions and internal pollution such as mould.

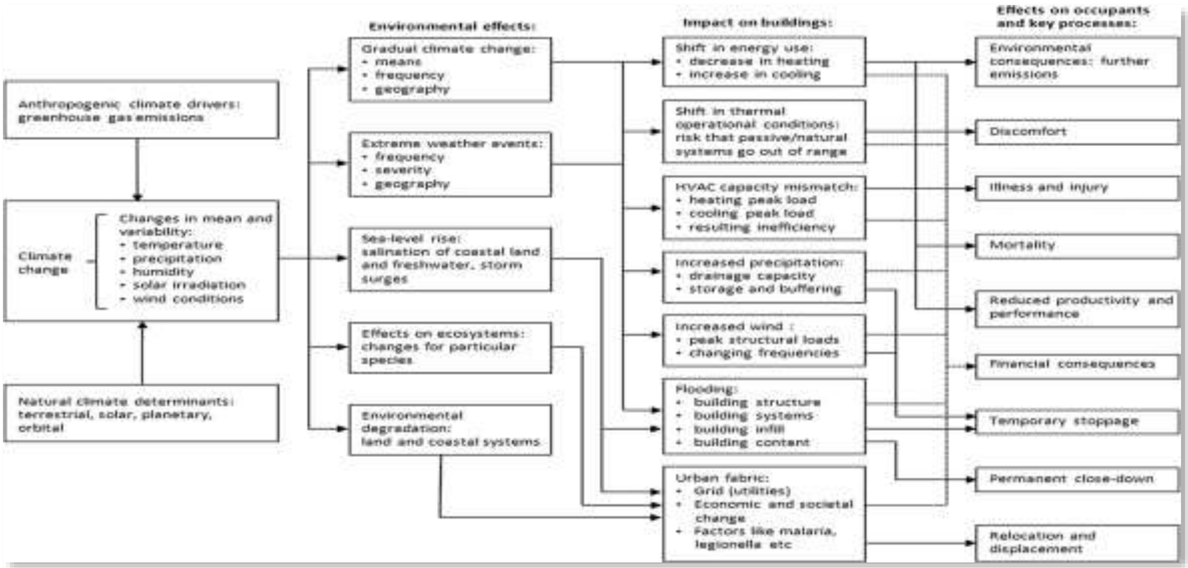

Figure 3-9 Schematic Overview of the Main Climate Change Impacts on Buildings; Source: De Wilde and Coley (2012)

Clearly, there is a sequential relationship between climate change scenarios and the building sector, with climate change patterns inducing crucial risks on the building sector and the building sector contributes to the main causes of climate change by increasing GHG emissions; however, the risks of climate change scenarios on buildings and real estate will be greater than the buildings' contributions to GHGs; therefore, there is a need to address the potential risks from climate change on the building sector in order to adapt policies and strategies, as well as to protect buildings and real estate.

Moreover, the importance of understanding the risks emerging from climate change patterns on buildings and real estate is to allow the adaptation of climate change to be a key consideration in the design stage of any construction project (Capon and Oakley, 2012). The adaptation strategies and policies need to be developed in order to deal with the implications of changing climate extremes; these considerations are many and will impact all sectors (Cheng *et al*., 2012). Furthermore, solutions and strategies to cope with the potential risks of climate change should take place with the interdependence of all sectors as this ensures a high chance of success in the effective adaptation on a long-term basis (Brown *et al*., 2011).

Therefore, it is crucial to identify the possible risks emerging from climate change scenarios on buildings and real estate in order to establish suitable strategies for adapting to and coping with such risks.

3.9.1 Types of the Risks on the Building Sector

As illustrated above, the climate change scenarios will have significant and direct risks on the building sector, leading to impacts on other sectors. For this reason, there is a need to investigate the possible risks emerging from climate change patterns on buildings and real estate in order to adopt suitable strategies and policies to cope with potential risks through mitigation and adaptation strategies. According to Hunt and Watkiss (2011), studies and research about the potential risks of climate change are still much less than required, especially in the building and energy sectors, when comparing with other studies related to health and water resources. Moreover, Hacker *et al.,* (2005) indicate that there is no sufficient information and data available in connection with the pace and magnitude of the risks emerging from climate change scenarios on buildings and real estate. This will result in exacerbating the risks on buildings, such as operational risks, which may include the fact that buildings become obsolete and are ultimately unable to perform their functional and design roles within their useful lifetime. This leak in information and data concerning emerging climatic risks on buildings and real estate will result in economic risks, such as costly and difficult retrofits.

Additionally, studies and researches centred on the risks emerging from climate change patterns on buildings and real estate are considered very rare, especially when associated with buildings' performance, energy usage and economic risks, as well as the extent of occupants comfort and discomfort (Crawley, 2003). There are four categories of emerging risk of climate change scenarios, which can impact business through their effects on buildings, including physical risks, regulation risks, reputational risks and litigation risks (Kwan, 2009; Liberty International Underwriters-LIU, 2010). According to Knobloch and Leurig (2010), there are several risks emerging from climate change scenarios, such as regulatory risks, competitive risks, liability and responsibility risks, and reputational risks. In the same vein, the risks of climate change scenarios data and investigation lead to assisting professionals and decision makers in the building sector to formulate and implement adaptation and mitigation strategies. This will help buildings and real estate to face and cope with different climate events (Garvin *et al*., 1998).

3.10 Summary of this Chapter

Clearly, there are no sufficient data and guidelines relating to the possible risks on buildings and real estate from climate change scenarios, which help and assist decisions and policy makers to adopt and develop strategies in the building sector in an effort to cope with such risks. De Wilde and Coley (2012) indicate that, at the present time, it is necessary that buildings and real estate are designed and built in consideration to climate change strategies in order to operate them successfully in any climate change events. Risks emerging from climate change will affect buildings and real estate in seven different ways, namely physical, operational, economic, occupant dissatisfaction, liability, reputational and regulation risks. These categories and associated emerging risks within each group will be identified and illustrated in the following chapters of this study. The investigation of such risks emerging from climate change scenarios will assist in identifying the main climate change risk management, which plays a vital role in the buildings and real estate adaptation and mitigation process. These strategies will be presented in the last chapter of the literature review stage of the research project. Overall, Table 3.2 below presented the main findings from literature review of this chapter along with the knowledge gap and research questions.

Issues Learned from the Literature Review	Argumentations	Research Gaps	Research Questions
What is the climate change and its possible scenarios?	As per the literature review discussed, the CC may have several patterns effecting buildings.	There is a need to investigate the potential climate change scenarios.	What are the possible CCP and what is the suitable classification that related to the building sector?
Is there a correlation between the building sector and the causes of climate change?	The relationship between buildings and the climate change is still in its infancy.	There is a need to find out the scientific correlation between buildings and climate change scenarios.	What is the association between CC and buildings; What is the negative contribution from buildings to CC?
Is there a method that bridges the gap between CCR and the building sector?	There are different manner that consider the threat of CCR on the building sector.	There is a need to investigate which method could have a clear impact on buildings and real estate.	What is the suitable and practical map that can help the building sector to avoid or cope with the CCR?
Is there a clear classification for risks that emerge from CCS on buildings?	The climatic risks on buildings and real estate could be classified in different ways.	There is a need to cluster the CCR related to buildings and real estate.	What are the potential CCR categories, which occur on the building sector?

Table 3.2 The Issues Learned from the Literature of CC

CHAPTER 4: PHYSICAL EMERGING RISKS

4.1 Introduction

According to Horváth and Pálvölgyi (2011), citing the work of Crisp (2003), climate change has varying risks on the building sector—particularly on buildings and real estate—by affecting its design, construction operation and maintenance process. In addition, with the severity of climatic disturbances, such as sea level rises and the increasing frequency and intensity of precipitation and windstorms, this will lead to increasing emerging risks of flooding, which will, in turn, result in damages to buildings and real estate in many different aspects, including physical damage, disruption to occupants and increased costs of damages (Szyman and McNamara, 2008). Furthermore, the fabric and structure of the buildings affected by key climate change impacts, such as flooding, storms and high wind speeds, all change the ground conditions, such as through wetting and drying, and will result in risks being inflicted upon the structures of buildings. In addition, changes in temperature affect the performance of buildings and real estate, such as in terms of internal overheating or cooling, and also increase the risk of fire—particularly during Summer (Capon and Oakley, 2012).

According to the CIBSE report by Hacker *et al.*, (2005), the potential physical risks of climate change on buildings and real estate can be divided into two groups, as follows:

Direct impacts including the following risks on the building sector:

- Impacts on structure, which include as a result of wind pressure, flooding and landslides.
- Impacts on constructions, such as through rain penetration, fabric damage and shading.

Indirect impacts refer to the indoor climate, such as in terms of temperature, humidity and mould.

Generally, by way of illustration, Capon and Oakley (2012) classify the impacts of climate change on the building sector as follows:

- Damage to the buildings, caused by extreme weather events, such as extreme rainfall, floods and storms.
- Damage to buildings, caused by changes in temperature, such as damage to foundations by changes in soil stability, damage to building fabric as a result of storms and heat effects.
- Pressure on green spaces and water availability through increasing temperature.
- Climate within the buildings caused by extreme heat waves and cooling.

It is notable that the main causes of the occurrence of emerging physical risks of climate change on buildings and real estate are extreme climate events, including flooding, storms and extreme rainfall, and changing average temperature. These causes are recognised as the main drivers or a key climate of the emerging climate change risks on the building sector. The following part will illustrate and discuss the emerging physical risks associated with climate change, as based on its damages being felt by buildings and the real estate sector.

4.2 Emerging Physical risks on the Building Sector

The risks emerging from climate change on buildings and real estate will be investigated based on the climate change driver, such as changing temperature, flooding and extreme events of climate change. The following section illustrates the potential physical emerging risks on buildings and real estate.

4.2.1 Emerging Physical Risks from Changes Average Temperature

The changes in temperature affect buildings and real estate both inside and outside. Inside risk comes in the form of either changing the climate or using more energy for cooling or heating, and increased risks of fire. Outside impacts include damage to the building's fabric and green areas around buildings and real estate. According to Snow and Prasad (2011), as based on Mills *et al*., (2001), it is stated that it is essential to bear in mind that minor increases in the average of temperature above a normal level can lead to dramatic increased risks of climate change, such as through increasing the intensity and speed of wind and storms, forest fires and flooding. Furthermore, the most important overheating risk on buildings is witnessed through an increase in dry bulb temperature. The quality of the design of the building is considered a main driver for its performance: for example, when considering the temperature in well-designed buildings, the internal temperature should be equal or less to that of the external temperature. In the case of a poor design, based on buildings' performance, however, internal temperature may be more than external temperature. However, in the case of an appropriate design, it is likely that the temperature of buildings will be kept lower than the daily average, or equal to such (Hacker *et al*., 2005). These will assist buildings and real estate in avoiding several physical risks, such as mould growth, materials' lower lifespan, and fire risks.

In addition, disturbances in temperature affect the atmosphere within the building, such as through high temperatures and the presence of a number of short-term extreme cold, leading to burst pipes (Garvin *et al*., 1998); consequently, this will decrease the overall durability and performance of the materials. Moreover, changes in temperature owing to climate change scenarios will impact buildings and real estate materials, such as by reducing their performance and life duration. For example, the risks of radiation will affect plastic materials, whilst the amount of salt in rainfall or flooding water will affect all buildings' materials (Ross *et al*., 2007). Figure 4-1 shows an example of various physical risks on property due to the performance and durability of external materials of buildings and real estate.

Figure 4-1 Some Effects of Climate Change on Roofs and Risks of Water Penetration.

Source: http://www.rtsroofs.com/services-austin-roofing-contractors.html

According to Garvin *et al*., (1998) and Ross *et al*., (2007), as based on the information and material gathered from the Foundation for the Built Environment report (FB2), as established in Table 4.1 below, the most emerging physical risks of climate change scenarios on buildings and real estate based on potential climate change patterns can be seen as follows:

Climate change Patterns	Emerging Risks
Dry and wet soil	➢ Damages to foundations. ➢ Increase land movement.
changes temperature (Maximum and minimum changes)	➢ Will affect heating, cooling and air. ➢ Affect internal thermal air movement.
Increase humidity	➢ Affect condensation and associated damage. ➢ Increase possibility of mould growth
Changes precipitation	➢ Affect water tables for foundations and basements. ➢ Increase the risk of leaks inside the buildings and causing more damages.
Strong Winds and Storm	➢ More pressure on building and its fabric. ➢ Risk of roof failures and damage to tiled roofs. ➢ More serious structural failure due to increase in frequency and severity of storms.
Flood Damage	➢ Vulnerable buildings will face increased risk of flooding.
Sun light and Radiation	➢ Affect the inside climate. ➢ Affect occupants comfort.
Dark Clouds	➢ Increase the need energy such as electric for lighting.
Rain Penetration and Water Damage	➢ Risk of water ingress. ➢ Rain penetration problems will increase.

Table 4.1 The Impacts of Climate Change Scenarios on Buildings;

Adapted from Ross *et al*., (2007); Graves & Phillipson (2000); Garvin *et al*., (1998).

Increases in rainfall, speed winds and solar radiation are all climatic factors affecting the overall durability of the external building fabric, and are considered to be the first line defence against the risks of climate change on buildings and real estate. Damage to building's fabric or an increased effect of climate change on buildings' facades can also affect the internal atmosphere as a result of changing temperature, wetness and sunlight. Furthermore, this leads to weakening of the durability of buildings and increasing rainfall, thus making it more likely that the outer surface will be penetrated, thus increasing the moisture, resulting in the growth of mould. Moreover, condensation and water penetration cause the corrosion of metallic items, such as brackets, fixings and frames, all of which weaken the building and reduce its lifetime and performance (Vivian *et al*., 2005).

Figure 4-2 below shows some cracks on building walls and ground due to land movement, induced by changes in the temperature of buildings and its structure.

Figure 4-2 Some Cracks and Breaks on Buildings from Climate Change; Source: Ross *et al.,* 2007).

According to Capon and Oakley (2012), extreme changes in temperature in buildings cause more thermal expansion, thus resulting in movements in the metallic of the building components, such as cladding. Moreover, this increases the rate of corrosion reactions—especially the building's components, which are expected to give a quick response to the risks of climate change, including plastics, windows, doors and pipes. Moreover, internal extreme temperature will increase indoor pollution by increasing the out-gassing of solvents from buildings' materials and furnishings (Garvin *et al.,* 1998); this results in increased fire risks within buildings and real estate (Tubb *et al.,* 2007). In addition, Roaf *et al.,* (2009) indicate that fire risks are significantly increased, with hotter dry seasons as the pace and magnitude of climate change crucial—especially the changing temperatures in relation to fire risks. For instance, in the UK between 1997 and 2002, there were 209,000 fire incidents, while in 2003, on the other hand, which is notably recognised as one of the hotter and drier summers, there were around 110,460 fires.

Furthermore, by way of illustration Table 4.2 below clarifies the risks emerging from climate change on buildings and real estate, and their components, structure and sub-structure:

Part of the Building	Impacts
Basements (sub-structure)	• Increased risk of heave or subsidence. • Increase ground movements due to increased drying of soils. • Water ingress. • Damages to finishes and stored items.
Mechanical and electrical services	• Reduce life or reliability of complex system due to uncontrolled temperature. • Safety implications.
Materials	• Plastics will have reduced life due to increased radiation and temperature. • Increase corrosion of metal components. • Timber may degrade quicker through increased biological and pest attack.
Roofs	• Increased risk of failures. • Increased pressure on building due to snow load and water absorption. • Penetrations of water and radiation.
Foundation and sub-structure (concrete)	• Increased risk of damage such as land movement. • Damages to foundation by subsoil water. • Carbonate concrete more quickly. • Cracking problems with concrete elements.
Structure/cladding membranes	• Increased risk of cracking in walls. • Damages to buildings fabric due to different thermal and moisture movements. • Plastics will degrade faster due to increased UV-B levels. • Surface coatings will degrade faster due to increased UV-B levels.

Table 4.2 Emerging Physical Risks on Buildings and Real Estates' Components; adapted from Garvin *et al.*, (1998); Graves & Phillipson (2000); Ross *et al.*, (2007).

Other emerging physical risks on buildings and real estate as a result of changing temperature is material degradation, such as timber. Changing the average temperature and level of humidity affects timber, causing timber corrosion and rot structure, leading to reductions in the performance the building's structure (Garvin *et al.*, 1998).

According to Snow and Prasad (2011), increased humidity within buildings will lead to increased possibility of mould growth, as presented in Figure 4-3, along with the reduced thermal performance of buildings and real estate. At the same time, the possibility of higher risks of fire will increase due to a decreased level of humidity in property. Furthermore, the extent to which buildings and real estate are vulnerable to the events of extreme changing temperature means the need for retrofitting mechanical ventilation will increase (Austin *et al*., 2008).

Figure 4-3 Mould Growth on Buildings' Walls; Source Environix (Undated).

It is clear that from the above illustration that the emerging risks of changing temperature on buildings and real estate impact both inside and outside buildings. The difference in temperature between the internal and external property is regarded as the dominant force of the physical risks of climate change on buildings and real estate. Extreme temperature rises within the building gave caused incidence cracks in walls and the façade, and the weakening of the materials and internal wiring, as well as reduced capacity of electrical systems, all of which will lead to the incidence of fires—especially during summer. From external buildings', the fabric is known to be the first layer facing such circumstances of climate change patterns. Changes in temperature will increase their vulnerability and shattering, thus leading to further breakthroughs of water and sunlight.

4.2.2 Emerging Physical Risks from Flooding

In the 21st century, owing to climate change, there might be huge increases in the consequences of flooding, which is a direct result of potential climate change scenarios, such as sea level rises, increased rainfall and extreme storm rainfall (Capon and Oakley, 2012). Moreover, rising rainfall levels and rainstorms, as well as acceleration in melting ice, results in a higher risk of floods, thus causing casualties and significant damages, impacting communities in all aspects (Mountain *et al.*, 2010). In addition, rises in sea levels and changes in the frequency and severity of storms lead to the aggravated risk of flooding (Vivian *et al.*, 2005). Flood is one of the most significant projected impacts of climate change scenarios due to the high expectations of sea level rises and increased intensity winter rainfall; this has been the subject of many recent studies and reports (Glynn, 2005). For instance, in the UK, the flooding of buildings is a perennial vital problem in most areas due to the obvious influence of climate change on the sea and rivers (Sanders and Phillipson, 2003).

Figure 4-5 Flash Floods in UK During 2011; Source: Snow & Prasad (2011).

Nowadays, flooding is recognised as the most significant risk across buildings and real estate, and will continue until the 2020s. It is expected that, between the 2050s and 2080s, flooding will pose one of the most significant threats on the buildings sector due to climate change (Twigger-ross and Orr, 2012). Furthermore, due to unusual climate change patterns, such as extreme precipitation and strong rain storms, increasing sea levels will be witnessed, subsequently augmenting risks from flooding and causing massive and costly risks and damages to buildings and real estate (Garvin *et al*., 1998). Based on the work of Building Research Establishment –BRE (1996), flooding occurs when there is a large surplus amount of precipitations which dilute concentrations of sea water or sewage as well as with silt and this water become more dangerous on housing and population. According to Sanders and Phillipson (2003), pointed out that the most crucial physical risks from flooding occurred on property are damages to internal decoration and plasterwork, floorboards and other finishes and furniture.

Figure 4-4 Example of Flood Risks on Buildings' Foundations in the UK; Source: BBC News (2012)

Moreover, flood waters are polluted and common contain silt or sewage, thus causing damage to buildings and real estate. For instance, Figure 4-5 above provides an example for one of the flash floods in the UK; this floodwater contained several pollutants, such as soil, sewages and silt. The risks and damages incurred from flood are limited to the ground and basement levels of property, which are exposed to the threat of flooding. The amount and magnitude of damages inflicted as a result of flooding can be measured based on the water level inside buildings (Ross *et al.*, 2007).

Furthermore, water damage from flooding affects building contents, such as walls and flooring, thus undermining foundations and contamination from sewage, soil and mud (Snow and Prasad, 2011). Figure 4-4 presents one of the most significant risks, which is the structural damage of buildings and real estate as a result of flooding. These types of risk will cause crucial damage to buildings' foundations, such as in the form of cracking, which will result in destroyed property. Floodwater penetrates buildings quickly, which will lead to extensive damage being felt by the building and its contents, such as damage to floors, walls and finishes, as well as structural damage, which increases depending on the flood severity and intensity.

Depth of Flood	Damage to Building	Damage to Services and Fittings	Damage to Personal Possessions
Below ground Floor	• Damage to building components • Entry of water to basements and floor voids • Foundations erosion • Deformation foundations components and Concrete	• Damage to electrical sockets and services in basements and cellars • Damage to floor coverings in basements and cellars	• Damaged to personal belongings and furniture in basements and cellars
Up to half a metre above ground floor	• Internal damages such as wall finishes and plaster linings • Floors and walls becomes saturated by water and sewage • Chipboard flooring likely to require replacement • Damage to internal and external doors and skirting	• Damage to downstairs electricity meter and consumer unit • Damage to gas meters, boilers and telephone services • Damages to carpets and floor coverings • Disruption white goods	• Damage to furniture and electrical goods • Damage to small personal belongings • Contaminated food in low cupboards
More than half a metre above ground floor	• Increased damage to walls and possible structural damage • Cracking and damages to windows	• Damage to higher units, electrical services and appliances • Disable services inside the building	• Damage to most of personal possessions • Damages to most of the furniture

Table 4.3 Emerging Physical Risks from Flood on Property; adapted from Wingfield *et al.,* (2005).

Most materials of buildings, such as plasterboard, affect and distort rapidly due to the absorption of large amounts of floodwater, which penetrates buildings and real estate through weakness points in facades, such as voids and cracks, which occurs due to external influences of climate change scenarios on buildings (Scottish Executive, 2004).

According to Wingfield *et al.,* (2005), in reference to the DTLR (2002), the most important driver of emerging risks from flooding on the building sector is the flood depth, particularly within buildings or real estate. The Table 4.3 above illustrates various emerging physical risks on property, as based on the flood level.

In addition, by referring to the report of Scottish Executive (2004), the risks from floods on the building sector depend on the characteristics of the flood, including the depth and duration of the flood, as well as water velocity. Generally, this can be classified into three main drivers of the emerging physical risks from flooding, as illustrated below:

- Shallow floods will crack the building through weak points, such as air vents and cracks in the building facade.
- Increased pressure on buildings and its structure will be experienced due to increases in the speed and depth of the flood, which normally are under one metre. In this case, the flood penetrates the building through several tracks, such as drainage pipes, from ground-floor toilets and through windows, causing more cracks to be inflicted upon the building as a result of increased water pressure, including debris and impurities in the flood waters.
- Increased damage and the severity of the flood on buildings will be recognised when the flood depth exceeds one metre, thus causing structural damage to the building, its fabric and foundations, resulting in the possibility of collapse, in addition to internal damage to buildings and their components. The probability of building collapse will increase when the pressure of flood is exerted on one side of the building.

With flooding effects felt by buildings, materials, such as masonry and concrete, are likely to expand and shrink as a result of wetting and drying, which subsequently leads to cracks and breakages in the structure of the building. Furthermore, floodwaters are different considering the amount of salt and sewage, which subsequently has an impact on the minerals, foundation and stabilisers of the property. Consequently, the components of the buildings and real estate become weak in terms of the resistance to external factors, and are responsible for speeding up erosion (BRE, 1996). In order to establish additional emerging physical risks on the building sector from flooding, the Scottish Executive (2004) presented more of these impacts on buildings and real estate, with their components highlighted as follows:

- Flooding which contain salt water cause surface powdering and flaking of soft brickwork with corrosive building facade.
- Metals erosion occurred by sea water especially in foundation and facade.
- Concrete expand depending on moisture and wetting and drying leading to cracking.
- Timber swells and distort due to wetting.
- Risk of timber decay in the long term due to difficulties in drying.
- Water retention by some isolated materials and mineral fibres, causing damage of these materials and lose their insulating properties

Clearly, the previous illustration confirms that flooding causes the demolishment and destroying of communities and population displacement due to its impacts and risks on the building sector. These emerging risks can affect the most important factors of buildings and real estate, such as the foundations and sub-structure, the fabric, and finishing materials. These physical risks lead to a reduced lifespan of the effected property and may, in turn, lead to the removal of such buildings and real estate due to the damage being inflicted upon their construction and components. There are many more risks recognised as emerging from flooding, including water penetration, pollution of water laden with soil, sewage and salts, and the destruction of underground services; therefore, flooding can be considered one of the most vital drivers of emerging physical risks on buildings and real estate.

4.2.3 Emerging Physical Risks from Extreme Events of Climate Change

The extreme events of climate change scenarios include unusual precipitation, strong storm and higher speed wind, as illustrated in the previous chapter. These extreme events of climate change lead to exacerbated emerging physical risks on the building sector, as well as the occurrence of other risks on buildings and real estate, as illustrated below.

The building sector adopted the historical recorded of wind speed in designing buildings; however, the prediction for the future indicates that extreme windstorm events will occur more frequently which result in serious damages to buildings and real estate (Szyman and McNamara, 2008). Windstorms are presently known as the costliest climatic events in the world due to its potential emerging risks on the building sector (Hunt and Watkiss, 2011). According to Austin *et al.*, (2008), has indicated that there is some evidence declared that a small increase in the level of wind speed may lead to occur crucial physical risks on the building sector.

The Australia Government Department of Climate Change—DCC, (2009) points out that disturbances in climate change scenarios result in a severity of storms and wind speed that lead to increased physical risks and damages on buildings and real estate, as shown in Figure 4-6 below. When the increases in wind speed are as much as 25%, the proportion of risks on buildings from this increase will be approximately 650%. Furthermore, it is very likely that approximately a million buildings have become exposed to the physical risks and damages from wind by just 6% increases in wind speed (Sanders and Phillipson, 2003).

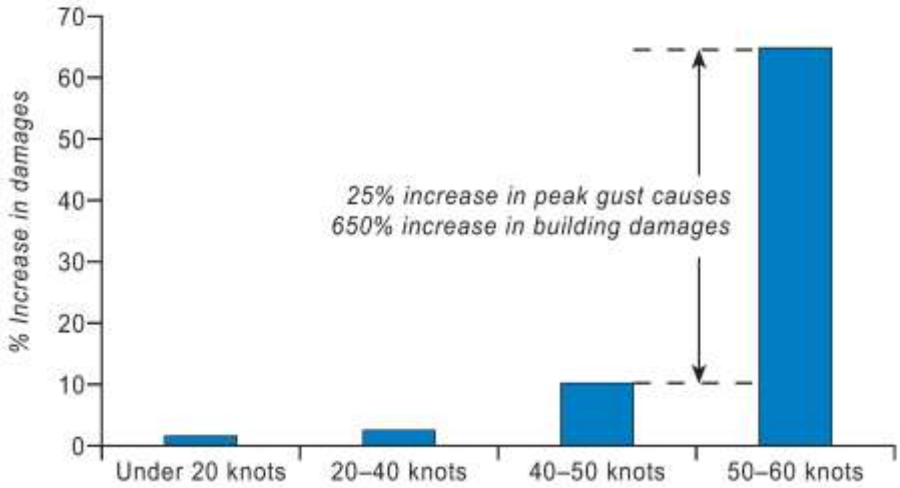

Figure 4-6 Amount of Damages on Buildings and Real Estate from Increased Wind Gust Speed.

Source: Department of Climate Change (2009) based on Insurance Australia Group 2003.

Likewise, increased wind speed and strong storms induce increases in emerging physical risks on property, including damage on roofs and crucial structure failure, as well as water penetration from rain through walls and around windows (Garvin *et al.*, 1998). Moreover, increasing wind speeds cause more pressure to be experienced by the facades of buildings and real estate, leading to breakthroughs. The wind penetration could laden dust and shell, leading to serious damage to buildings' structure and fabrics, with wind also harmful to the internal atmosphere of the property (Roaf *et al*., 2009).

According to Ross *et al.,* (20007), the main risks associated with storms can be seen on the roofs of buildings and real estate; however, this depends on the speed of the winds and the extreme precipitation often accompanied by a shower of hailstones. Moreover, the increased rainfall and high temperatures will directly affect the cladding of property, which subsequently leads to the weakening of its resistance to different climatic conditions, as well as increases in the speed of wind, which leads to rises in the possibilities of cladding system failure across buildings or real estate (Garvin *et al.*, 1998). Furthermore, windstorms with rain are recognised as the climate change patterns most seriously affecting buildings facades due to their importance for moisture source through the buildings (Blocken and Carmeliet, 2004). An increase in the humidity within the building may be witnessed as a result of heavy rain, along with the breakthroughs that causes condensation. Consequently, these result in a range of emerging physical risks on buildings' fabric, such as the growth of mould and wood-rot, cracks in the walls, and the corrosion of various elements and minerals, all of which subsequently cause the cracking of the bricks of the property (Capon and Oakley, 2012).

Moreover, increases in the intensity and magnitude of rainfall on the building sector can lead to an insufficient drainage system, such as that on roofs, causing serious damage on the buildings and real estate (Graves and Phillipson, 2000). This leads to increases in the possibility of water ingress within the property, assisting in mould growth. Additionally, there is extensive degradation and damage to the building sector every year due to the emerging risks of extreme events of climate change. One of the serious risks and damages to the cladding and external walls of the property, as a result of frost damage, occurred as a result of water penetration through exterior walls (Lisø *et al.*, 2003). In much the same way, changes in freeze-thaw caused major risks to be felt by some materials of buildings and real estate, particularly external parts and elements (UKCIP, 2003).

Figure 4-7 Damages of Windstorms to Roofs; Source: Ross et al., (2007).

Essentially, the emerging physical risks associated with extreme events of climate change scenarios on the building sector are limited to the structure of the property and its fabric, through the presence of breaks and cracks, as shown in Figure 4-7 above. These climatic events cause the accumulation of water on roofs or absorbed by the roof cover and this will increase the weight of roofs and increases the probability of falling or imbalance of the property as well as reduce the ability endurance of external fabric (Ross *et al*., 2007).

Furthermore, extreme snowstorms will result in increased the loads on roofs and lead to a roof failure and collapsing (Lisø *et al*., 2003).

Figure 4-8 Example of Road and Pavements Cracking; Source: BBC News (2012)

The impacts on buildings from extreme events of climate change are based on the strength and level of these events, such as strong rainstorm or extreme high-speed wind. These weather events affect buildings and related services and facilities: for example, storms and cyclones damage building components, such as through cracking fabric and roofs, and increased pressure on external walls. At the same time, these events will damage and destruct plants and green areas around buildings and real estate with damages inflicted on roofs and other components, including cracking pavements and the removal of service grids, as presented in Figure 4-8 above. According to Vivian *et al.,* (2005), the Figure 4-9 below illustrates some of the emerging physical risks facing the building sector from different climate change scenarios.

There are other potential emerging physical risks stemming from extreme events of climate change on buildings and real estate. According to Sanders and Phillipson (2003), the extreme events of climate change can occur as a result of the coastal erosion due to the frequency of storms, along with increased proportions of salt in rainstorms, which can cause damage to external parts of property, such as roofs, walls and windows, and to internal plasterwork and finishes.

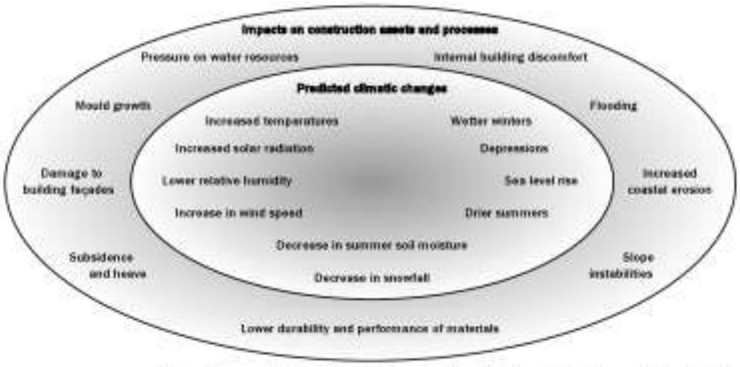

Figure 4-9 Predicted Climate Changes and its Impacts on Built Environment; Source: Vivian *et al.,* (2005).

There is also a group of buildings that are significantly affected by the risks emerging from climate change scenarios; these are historical buildings. According to Horváth and Pálvölgyi (2011), the historic buildings are considered strongly sensitive and vulnerable to the physical risks from climate change scenarios. Additionally, historical buildings will not able to adapt with the rapid changes in climate change scenarios. Moreover, old buildings and those built during periods of poor quality of construction (historical buildings) are recognised as less able to cope with the risks emerging from climate change, especially in the case of wind storms (Austin *et al*., 2008). This is due to several reasons, such as building materials used originally, which could have been centuries prior or which would have been used for the repair and preservation of such buildings. These materials are selected for adapting to certain conditions of climate change scenarios, along with being in line with the nature and character of historical buildings. Consequently, historical buildings become more vulnerable to the risks emerging from climate change in the building sector (Sanders and Phillipson, 2003). According to the UK Climate Impact Programme (UKCIP, 2003), it has been declared that there has been an increase in affected historical buildings as a result of the extreme events of climate change, such as flood storms and increased precipitation, subsequently leading to water saturated in the fabrics of such buildings. Additionally, the most crucial physical emerging risks on historical buildings include the erosion of the fabric and the destroying of parts of such buildings due to flooding events. This leads to changes in interior design as a result of increased moisture, along with the appearance of mould, which constitutes a serious threat to walls and internal parts of the historical buildings (Sanders and Phillipson, 2003).

4.3 Summary of this Chapter

It is obvious that the emerging physical risks from CCS affect buildings and real estate in many ways, such as affecting property or even its vital parts and elements, such as sub-structure, fabric, facades, roofs and materials. Such risks become a real challenge as the building sector needs to deal with these in order to protect and develop buildings and real estate in different climatic conditions. Extreme events of climate change scenarios play a vital role in emerging physical risks, including storms, windstorms and an increased level of precipitation, which will lead to flooding.

In short, Table 4.4 indicated the main observations from reviewing literature in this field. Moreover, the emerging physical risks are summarised in Table 4.5 below. In addition, such emerging risks affecting buildings and real estate resulting from CCP will also have a significant operation risks on buildings and real estate; this will be discussed and illustrated in the next chapter.

Issues Learned from the Literature Review	Argumentations	Research Gaps	Research Questions
How can the CCR affect buildings and real estate?	There are many ways that CCR can threat the building sector.	There is a need to investigate the potential CCR on buildings and real estate from many aspects.	What are the possible risks from climate change that disrupt and affect the building sector?
What are the physical risks and impacts?	As literature review discussed in this chapter, physical risks that related to the damages emerging from CCS on property themselves or on their component including elements and materials. Moreover, physical risks are considered as the most important risk category from CCS.	There is a need to clarify the physical risks and damages from buildings perspective	• How to quantify the physical risks? • What is the theoretical and practical way to identify the physical risks on buildings?
What are the main drivers of physical risks occurrence?	As per the literature review discussed, the physical damages can occur due to CCS such as changing temperature, flooding and extreme events of CCS.	There is a need to uncover the potential physical risks occur on buildings and real estate	What are the possible emergence physical risks and their occurrence timeframe?
Is there an agreed list or classification of the emerging physical risks and their expansion?	As per the literature review discussed, the physical risks measured based on the extent of damages caused on buildings and their components, which often be felt and clear due to CCS.	There is a need to determine the related emerging risks occur from CCS on buildings and real estate	What are the other dimensions of physical risks in the building sector?

Table 4.4 The Issues Learned from the Literature of Physical Risks

	Emerging Risks identified		References
Physical Risks	**1**	Cracking of building fabric	Capon & Oakley (2012); Ross *et al.*, (2007); (Vivian *et al.*, 2005); Scottish Executive (2004); Sanders & Phillipson (2003); Garvin *et al.*, (1998)
	2	Cracking or melting of pavements	Twigger-ross & Orr (2012);
	3	Scour to structures (from intense rainfall)	Austin *et al.*, (2008); Graves & Phillipson (2000); Garvin *et al.*, (1998)
	4	Disposal of debris including hazardous materials (from windstorms)	UKCIP (2003)
	5	Increased fire risks	Snow & Prasad (2011); Roaf *et al.*, (2009); Tubb *et al.*, (2007); Garvin *et al.*, (1998)
	6	Potential for increased odour problems	Austin *et al.*, (2008); Sanders & Phillipson (2003)
	7	Reduced asset life	(Vivian *et al.*, 2005); Scottish Executive (2004)
	8	Rapid asset deterioration	Vivian *et al.*, 2005
	9	Reliability of mechanical and electrical services in buildings	Twigger-ross & Orr (2012); Austin *et*

			al., (2008); Ross *et al.*, (2007); Graves & Phillipson (2000); Garvin *et al.*, (1998)
	10	Increased capital expenditures due to physical risks	Szyman & McNamara (2008)
	11	Potential need for retrofitting mechanical ventilation	Twigger-ross & Orr (2012); Austin *et al.*, (2008);
	12	Increasing subsidence and heave movement	Twigger-ross & Orr (2012); Sanders & Phillipson (2003)
	13	Damage to building foundation due to subsidence and heave movement	Twigger-ross & Orr (2012); Sanders & Phillipson (2003)
	14	Damage to building facades due to subsidence and heave movement	Sanders & Phillipson (2003)
	15	Increasing soil shrinking and swelling	Austin *et al.*, (2008); Sanders & Phillipson (2003)
	16	Damage to underground services	Sanders & Phillipson (2003)
	17	Surface water flooding	Austin *et al.*, (2008); Sanders & Phillipson (2003)
	18	Groundwater water flooding (from rising groundwater)	Austin *et al.*, (2008);
	19	Water ingress to facades	Austin *et al.*, (2008); Scottish Executive (2004); Sanders & Phillipson (2003)
	20	Water ingress to roofs	Austin *et al.*, (2008); Sanders & Phillipson (2003)
	21	Inundation of basement and ground floor	Sanders & Phillipson (2003)
	22	Vulnerability of services and plant	Vivian *et al.*, (2005); Scottish Executive (2004)
	23	Increase in the cost of materials supplies	Hunt & Watkiss (2011); Szyman & McNamara (2008)
	24	Saline water intrusion	Scottish Executive (2004); Sanders & Phillipson (2003)
	25	Corrosive saline atmospheric exposure	Austin *et al.*, (2008); Sanders & Phillipson (2003)
	26	Increase of acid rain weathering on building fabric	Scottish Executive (2004)
	27	Increase of defective building elements due to unforeseen weather conditions	Capon & Oakley (2012); (Vivian *et al.*, 2005); Scottish Executive (2004)
	28	Extreme exposure of building shell to dust	Roaf *et al.*, (2009)
	29	Increase of latent defect problems	UKCIP (2003); Sanders & Phillipson (2003)
	30	Damage due to high snow load on buildings	Hacker *et al.*, (2005); Lisø *et al.*, (2003)
	31	Damage to building assets from frost/snow	Lisø *et al.*, (2003)
	32	Increase of damp, condensation and mould problems in buildings	Snow & Prasad (2011);
	33	Erosion of historic building fabric	Horváth & Pálvölgyi (2011); Austin *et al.*, (2008); Scottish Executive (2004); Sanders & Phillipson (2003); UKCIP (2003)
	34	Lightning strike damage to buildings during storms	Capon & Oakley (2012)
	35	Slope instability	Scottish Executive (2004);
	36	Insufficient roof drainage in storms	De Wiled &Coley (2012); Vivian *et al.*, (2005); UKCIP (2003); Graves & Phillipson (2000)
	37	Decreased durability and performance of materials	Capon & Oakley (2012); Ross *et al.*, (2007); Vivian *et al.*, (2005); Scottish Executive (2004); Sanders & Phillipson (2003); Garvin *et al.*, (1998)

Table 4.5 The List of Identified Emerging Physical Risks on Buildings and Real Estate

CHAPTER 5: OPERATIONAL EMERGING RISKS

5.1 Introduction

Operation is the core function of buildings, which means the working ways and processes of buildings and their facilities and characteristics. The emerging operational risks on buildings and real estate from climate change scenarios might be paralysing its facilities, thus reducing the extent of its benefit and leading to greater consequences being felt by buildings and real estate and their occupants. According to De Wilde and Coley (2012), the consequences of climate change scenarios on the building sector will affect the performance and operation process.

In this section, the operational processes relating to the building sector will be discussed; this will lead to and assist in the identification of the emerging operational risks from climate change scenarios on buildings and its facilities.

5.2 Buildings Operation Concept

Operation, as defined in the Oxford dictionary, is *'the action of functioning or the fact of being active or in effect; an active process'* (Stevenson, 2010). In addition, from a buildings perspective, operations can be defined as all services required in buildings in order to ensure that the facilities of the building work properly and in the ways in which they were designed. This will include day-to-day operations of the building facility (Sapp, 2013). Moreover, after the completion of the construction work in the building, the occupancy phase begins, which encompasses the installation and operation of all the equipment and elements required for operate the building (Garcia, 2013). There is a correlation to be made between the operation process and facilities management of the buildings and real estate. According to the British Institute of Facilities Management (BIFM, 2013), facilities management refers to the integration of processes in buildings, which includes the maintaining and development centred on reaching the agreed services, which will help to improve the overall effectiveness of the primary functions and services of the building. In addition, the significance of properly operating and maintaining buildings is centred on ensuring the ability to perform as intended as in their art design and construction (Lai, 2010).

In this research project, the operational process of buildings and real estate will be used to refer to the daily works and activities of the full operation of buildings and real estate, as well as their facilities, in order to perform their intended design and functional roles.

5.3 The Building Operational Process

Based on the International Facility Management Association, Finch (2004) states that facility management includes a wide range of different works and activities, as listed below:

- Annual planning;
- Financial planning;
- Real estate acquisition and/or disposal;
- Work specifications, installation and space management;
- Architectural and engineering planning and design;
- New construction and/or renovation;
- Maintenance and operations management;
- Telecommunications integration, security and general administrative services.

Moreover, facility management within buildings and real estate comes as part of the operational stage, with energy resources and maintenance activities. In addition, under each one of these operational elements, there is a list of activities, as shown in Figure 5-1 below.

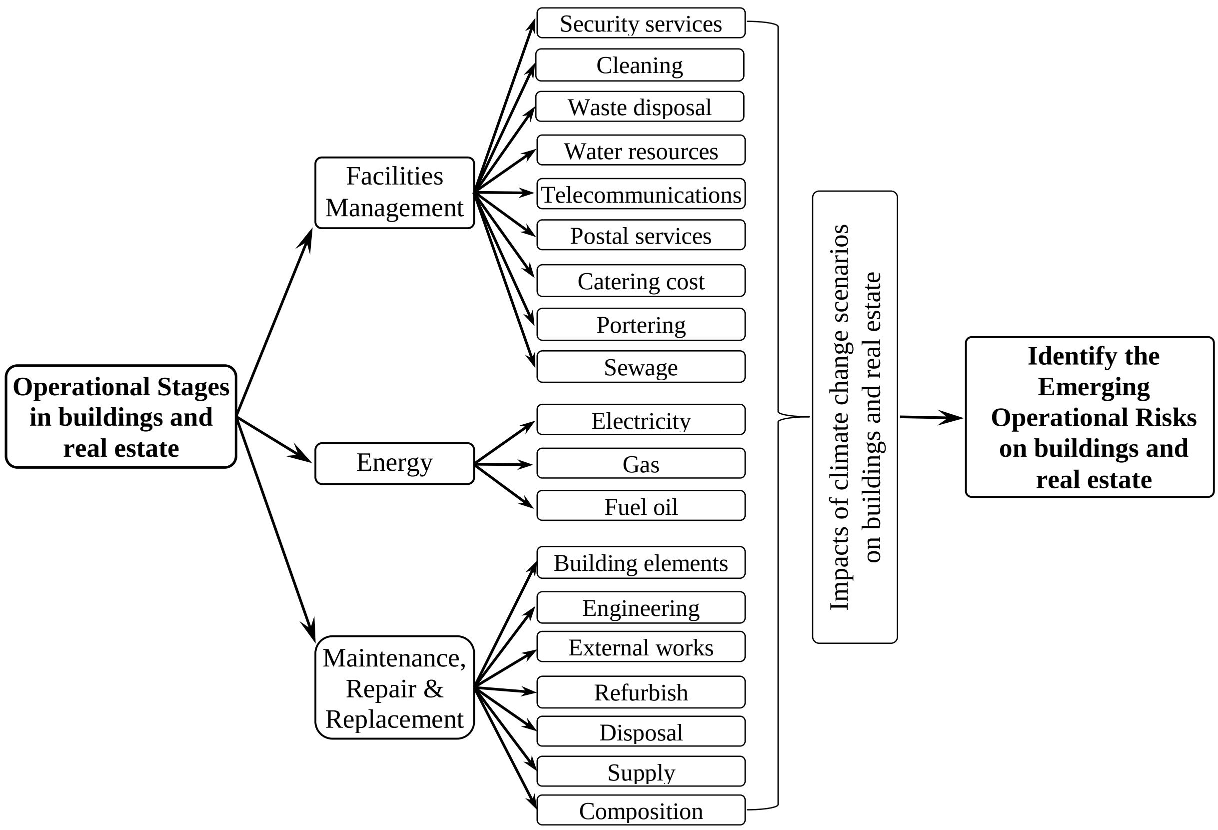

Figure 5-1 The Elements of Building Operational;

Source: adapted from (Boussabaine & Kirkham (2004); Graves & Phillipson (2000).

This classification of the operation phase in buildings and real estate will be adopted in this part of the research in an effort to identify the emerging operational risks on property from CCP.

5.4 Emerging Operational Risks

Buildings and real estate in the operation phase will induce significant risks as a result of climate change scenarios, including energy, facility management, water, and maintenance (Defra, 2012). According to Hertin *et al.*, (2003), it is noticeable that the operating and technical managers in the building sector are more concerned than others regarding the seriousness and impacts of climate change patterns on property; therefore, it would be useful to consider the extent to which the risks emerging from climate change scenarios impact at the functional and operational phases of buildings and real estate.

Built on the classification shown in Figure 5-1, the emerging operational risks on buildings identified as a result of climate change patterns will be clustered into three groups, as shown below in Figure 5-2. Importantly, these emerging operational risks will grouped into operational risks on facilities management (FM), risks on energy resources and risks on maintenance activities. These emerging operational risks on buildings will illustrated and discussed below in more details.

Figure 5-2 Classification of Emerging CC Risks on Buildings' Operation

5.4.1 Facility Management (FM) Risks

As noted in the earlier stages of this research, climate change encompasses different patterns, such as changes in temperature, and flood and extreme weather events, all of which will increase the pressure on water resources. According to Snover *et al.* (2003), during the next decades, the impacts of climate change are projected as having critical risks on water resources, leading to rises in the competition on available water amongst water users. It is widely known that facility management in the building sector is significantly reliant on water supply, as it is crucial in operation processes. Accordingly, the effect and pressure on water resources will affect buildings and real estate, especially when property requires water for its operations (Szyman and McNamara, 2008). This problem is exacerbated by the availability of water resources, which is affected by changes in rainfall, which directly impacts the availability of water sources. For this reason, buildings and real estate—which depend on the availability of water—will be affected by water scarcity; this negatively impacts the efficiency of the performance and operation of such buildings (Austin *et al.*, 2008). In the UK, for instance, as noted by Hulme *et al.* (2002), by the 2050s, it is expected that annual average rainfall will be reduced by approximately 10%. These climatic patterns will affect the buildings operational phase in different ways, one of which is through facility management and its components, such as water resources and facility disturbances. According to Scottish Government (2009), unexpected increases in sudden precipitation will mean the sewerage services and drainage systems within buildings will become unable to manage, leading to more damages being experienced by them.

The impacts of various climate change patterns affect water sources in terms of availability and quality of water, forcing institutions in the countries, whether public or private to reduce water consumption and follow especial programs in order to restrict water demand especially in their estates and buildings (Arnell, 1999). According to Bergkamp *et al.*, (2003), who stated that one of the important findings from Central American Dialogue on Water and Climate, which were in November 2002, is that the risks of climate change scenarios on water resources will threaten all sectors in different societies. Moreover, these climate change impacts on water resources and drainage and sewerage systems will lead to more considerable cost for many sectors (Scottish Government, 2009). Moreover, predicted climate change scenarios could change the availability of water resources and change its quality. As a result of these climatic risks on water the availability of water to use will decrease. Especially, in construction industry where they heavily reliant on the availability of water.

Consequently, the water availability will affect the construction process of buildings and infrastructure as well as the on water that use within existing buildings (Vivian *et al.*, 2005). Water scarcity due to the risks of climate change on water sources, such as drought and water contaminated with sewage or oils due to floods, as presented in Figure 5-3 below, will lead to the disruption of operations amongst buildings, preventing them from achieving the necessary performance or providing unsatisfactory services. This results in increases in water costs, as well as increased prices of ways to maintain water or water discharge, which call for contributing actions to solve the problem, such as restricting the use of water and searching for other alternatives.

Figure 5-3 Floods Contaminated with Oil, Downtown Franklin; Source: (Bergkamp et al., 2003) pp.14

According to Keim (2008), the crucial risks on the public as a result of flooding include the disruption of sewage services and collection of solid waste. Moreover, in different climate change patterns, such as increases in drought, for example, in some locations, the frequency of water shortages might increase owing to these climate risks, subsequently leading to more restrictions on water usage (EPA, 2009; CCRA, 2012). Vivian *et al.*, (2005), indicate that the risks from water availability within the building sector potentially resulting due to the extra costs of providing water to areas suffering from water shortages. For instance, in South-East England, by 2100, the annual economic losses within the built environment as a result of water shortage are expected to be between £40 million and £400 million; therefore, the costs for eliminating the water shortage issue would be increased as it would be between £6 million and £40 million each year (Wade *et al.*, 2006).

The risks emerging from climate change scenarios on buildings will spread, reaching many facilities of buildings and real estate, such as distribution communication services, facilities and access to other services. With reference to Chalmers *et al.*, (2009), due to the influences of climate change patterns on the environment, such as flooding and storms, access to services and its quality, such as water resources, energy, and transport and communications, will be damaged, subsequently inducing further difficulties. Correspondingly, the buildings services will be affected by such climatic conditions, leading to a reduction in access to the buildings and their facilities and infrastructure. Moreover, mobility to get safe areas or even access to services and infrastructure will become problematic both during and after extreme events of climate change; therefore, the reduction of access to facilities and services would be possible owing to such climatic patterns (Chalmers *et al*., 2009).

Consequently—and with previous risks of climate change patterns on the buildings' operation phase taken into account—the stoppage of buildings or part of it will increase, which will disrupt their operation conditions, as it is public or private buildings. According to Tubb *et al.,* (2003), who have established from their research study that the current impacts from climate change patterns will have an impact on access to buildings—even by either occupants or staff—results in an increase of the disruption of services and increased temporary closure of buildings. Furthermore, unexpected climate change impacts buildings, which will require unscheduled maintenance works, resulting in disruption to the use of buildings or limitations on the use of their facilities (Vivian *et al*., 2005). Such climatic risks on the operation of buildings and real estate will result in greater risks on the energy supplier, as will be illustrated in the next section of this part of the research.

5.4.2 Energy Supplier Risks

The energy is important for the operation phase in buildings and real estate, as it is responsible for lighting, cooling and heating, and further contributes to running most of the facilities within the building sector. Furthermore, the operations and control system of the buildings and real estate are strongly linked with energy consumption within buildings, together with the integrated performance of the buildings and real estate (Pisello *et al.*, 2012). According to Pérez-Lombard *et al.,* (2008), around 40% of all energy resources are used by the building sector. Importantly, there is a clear correlation between climate change scenarios and demands of energy in the building sector, based on the energy needed for heating or cooling inside buildings (Lough *et al.,* 1983; Hunt and Watkiss, 2011). However, the risks emerging from climate change patterns on buildings' operation will affect the energy within buildings and real estate, such as by decreasing its level due to higher consumption. For example, in the work place, heat weaves lead to more risks on energy, especially in extreme climate events, which increases the consumption of energy use in creating a comfortable place to work (CCRA, 2012). Changes in climate are likely to influence both the heating and cooling energy demands within buildings and real estate: for example, in naturally ventilated buildings, as a result of overheating through long periods of drier summers, more energy cooling systems will be required in order to provide comfortable conditions within such buildings and real estate (Capon and Oakley, 2012). According to Wilby (2007), the key emerging risks from higher temperatures in the building sector include increased energy consumption and electricity for cooling. In this same vein, the increased energy demand is based on how the building's occupants cope with internal climate and accordingly control the building conditions in terms of climate so as to become more comfortable by using energy for cooling or heating. As a result, more energy use is needed in order to create a more comfortable environment.

In addition, the demand for more energy within buildings and real estate is impacted by three

Figure 5-4 The Traditional Three-way Interaction Between Climate, Building and Occupants; Source: Roaf *et al.*, (2005).

factors, namely climate condition, occupants and property, as shown in Figure 5-4 above (Roaf *et al.*, 2005). This increase in the energy demand will influence the availability of energy, leading to unexpected increases on cost. According to the CCRA summary report (2012), the changes of temperatures within buildings adversely affect the occupants, which in turn pushes them to rely on energy—even for cooling or heating—so as to create a comfortable atmosphere for them. Energy consumption in this situation results in significant increases in energy costs, especially in business buildings and real estate, subsequently inducing more economic problems for the building sector. As a result of the change in energy demand levels, as experienced by buildings and real estate due to the impact of risks emerging from climate change patterns, the average energy demand increases sharply for cooling whilst slightly falling for heating; thus, this oscillation in energy usage will have a clear impact on energy costs, leading to more difficulties in the energy supply chain in particular (Skea, 1992). These risks and problems on energy supply will lead to increased pressure on electricity: for instance, Rosenzweing *et al*., (2001), as cited in Hunt and Watkiss (2011), state that, in New York City, the daily load on electricity for air conditioning will increase by around 12% in the 2020s and approximately 17% in the 2080s due to heatwaves resulting from climate change scenarios. Services in buildings and real estate, such as electricity, is likely to disrupt, or blackouts due to different climate change scenarios, such as flooding and extreme events, may require high costs for repair or replacement (Graves and Phillipson, 2000). Furthermore, air conditioning in buildings is known as the area of the rapid growth of electricity consumption and increased proportion of electricity usage with high temperatures (Skea, 1992). Theoretically, this means that, in the case of low temperatures in buildings and real estate, there is the consumption of energy for heating and vice versa: as the temperatures rise, more electricity consumption for cooling will be witnessed. Changes in extreme temperatures and other climatic conditions will increase the seasonal demand of energy, whether for heating in Summer or cooling in Winter; this will result in different convection within buildings and real estate, ultimately causing losses in electricity (Grossman, 2012).

It is widely accepted that the effects of climatic patterns will lead to interruptions and delays on the building sector, especially on the construction process, subsequently leading to more associated costs (Vivian *et al*., 2005). Similarly, in the operation phase of buildings and real estate, the risks of climate change events interrupt its functions due to an influence in related sectors, such as supply chain and energy supplier. According to CCRA (2012), it is projected that increases in precipitation, more extreme climate events and wetter winters will increase the threats to the business, leading to more disruption, including across the supply chain.

It can be concluded that energy consumption in buildings and real estate is based on both the operation process—which might include more usage of energy in order to successfully operate the facility—and the occupants in terms of their energy usage for heating, cooling and ventilation, or even other uses, such as lighting. Climate change patterns affect energy consumption in the building sector by increasing its severity, which leads to an increase in the intensity of energy consumption in buildings and real estate. Increased energy consumption is highly projected to increase the pressure on the availability of energy sources, which will result in greater costs of energy, as well as an increased chance of frequent malfunctions and disruptions. This will cause additional costs for repairs. This likely increase in energy prices will be due to the emerging risks of various climate change patterns on energy supply chains. Such operational risks on buildings will affect the buildings' operations, potentially resulting in increased maintenance activities and costs, whether for repair or replacement. This will be discussed in the next section of this chapter.

5.4.3 Maintenance, Repair and Replacement Risks

Regular maintenance for buildings and real estate are required in order to ensure that the buildings remain and work as they are designed and built to do so. However, climate change scenarios, such as floods, heavy precipitations and extreme climate events, could have an impact on the maintenance activities for buildings. According to Hertin *et al.,* (2003), the building sector is the sector most vulnerable to the impacts from climate change scenarios, particularly those related to maintenance and repair damages caused by extreme events, as well as the increased costs for repair and replacement. In addition, buildings and real estate, as well as their facilities, need to be maintained regularly and determine the vulnerable elements of property in order to avoid any risks from climate change impacts on buildings and real estate, and their elements and facilities. Importantly, this will assist in buildings operations performing as designed (Graves and Phillipson, 2000; Wingfield *et al.*, 2005). According to Graves and Phillipson (2000), climate change risks on buildings will significantly influence buildings in terms of performance and costs, resulting in more required maintenance works and greater costs as a result of such works, including the loss of availability across buildings' facility. For example, in the case of buildings' exposure to extreme climate influences, such as floods and heavy driving precipitation, more damages will be recognised, thus requiring additional maintenance tasks to avoid any disruption on the building operation (ibid). According to Australian Department of Climate Change (DCC, 2009), more of the risks emerging as a result of climate change scenarios relating to the operation and maintenance stages in the building sector are as follows:

- Increased maintenance, repair and replacement due to frequent damages.
- Increase in maintenance costs due to damages on property.
- Reduction in operate of facilities due to damages.
- Reduction in use of buildings and real estate due to inundation, flooding, ground movement and structural integrity.

Moreover, the London Climate Change Partnership report (2002) indicates that the effects of climate change scenarios, such as flooding, on the operations of the building sector will be exacerbated, including disrupting power lines and telecommunication services and linkages.
It is expected that the additional maintenance or adopted retrofit for buildings to cope with different climate change events will lead to considerable costs (Scottish Government, 2009). Moreover, in the case of damages or fails on buildings elements due to the risks of climate change scenarios and prior to reaching its projected lifecycle, there will be a significant increase in maintenance costs (Vivian *et al*., 2005). For example, in the UK, the annual loss for buildings maintenance due to the effects of climate change are likely to reach approximately £5 billion, whereas the maintenance cost of roofs only will be subject to £2.5 billion per year (Graves and Phillipson, 2000). In addition, the frequent rise in the maintenance activities of buildings, including changes in some of the elements, will require significant additional maintenance works, which increase maintenance costs and adversely affect buildings' lifecycles and their services provided (Vivian *et al*., 2005).

5.5 Summary of this Chapter

It is obvious that CCR on buildings and real estate may be considered significant challenges to the operation phase of the building sector. Such challenges will threaten the operation condition by affecting facility management, energy consumption and maintenance tasks within buildings and across real estate. The risks of the different climate change patterns on property—notably related to the buildings' operation condition—are considered to be emerging operational risks on buildings and real estate, and their facilities. These emerging operational risks are summarised in Table 5.2 below along with Table 5.1, which presented the issues, arguments and knowledge gap learned from this chapter. Moreover, such risks on buildings and real estate result from climate change scenarios, which will incur economic impacts on the building sector and other associated sectors. This will be discussed and demonstrated in the next chapter.

Issues Learned from the Literature Review	Argumentations	Research Gaps	Research Questions
What is the operational risks; and what is the potential risks from CCS on operation processes within buildings?	As per the literature re-view discussed in this chapter, there is no clear definition for operational risks in the building sector as well as there are different driver of such risks.	There is a need to investigate the operational risks and to establish a scientific definition for this type of risks.	• What are the operational risks emerging from CCS? • How to identify the operational emerging risks?
Is there any time scale for occurrence of operational emerging risks?	As literature review discussed in this chapter, there are no fixed period of the occurrence of operational risks as their emergence based on the pace and magnitude of other risks such as physical damages on property.	There is a need to find out the occurrence time scale of operational risks that arise from CCS.	How to measure the emergence of the operational risks?
What are the determinants of the emergence of operational risk?	As discussed in this chapter, there is no clear trends in order investigate the operational risks from CCS on buildings.	There is a need to establish a practical way in identifying the emerging operational risks.	What is the conceptual manner to uncovering the operational emerging risks and their occurrence time scale?

Table 5.1 The Issues Learned from the Literature of Operational Risks

		Emerging Risks identified	Reference
Operational Risks	1	Increasing water costs	Pérez-Lombard *et al.*, (2008); Wade *et al.*, (2006)
	2	Water use restriction	CCRA (2012); EPA (2009); Arnell (1999)
	3	More frequent mechanical breakdowns	Vivian *et al.*, (2005)
	4	Reduced access to facilities	Chalmers *et al.*, (2009)
	5	Reduced access to infrastructure	Chalmers *et al.*, (2009)
	6	Increased downtime	Tubb *et al.*, (2003)
	7	Increase in the cost of waste water discharge	Scottish Government (2009); Chalmers *et al.*, (2009)
	8	Temporary closure of facilities	Vivian *et al.*, (2005)
	9	Disruptions of telecommunication services	LCCP (2002)
	10	Increase in energy use	Wilby (2007); Capon & Oakley (2012)
	11	Higher energy prices	CCRA (2012)
	12	Electricity brownouts and blackouts	Grossman (2012); Graves & Phillipson (2000); (Skea, 1992)
	13	Increased reliance on mechanical cooling	Skea (1992); Hunt & Watkiss (2011)
	14	Increased costs due to alternative short-term supplies	Graves & Phillipson (2000)
	15	Interruption of supply chain	Vivian *et al.*, (2005); (Skea, 1992)
	16	Higher costs of repair	Graves & Phillipson (2000)
	17	Increased maintenance regimes	Wingfield *et al.*, (2005)
	18	Increased slips and falls	(Skea, 1992)

Table 5.2 The List of Identified Emerging Operational Risks on Buildings and Real Estate

CHAPTER 6: FINANCIAL EMERGING RISKS

6.1 Introduction

Climate change patterns have become a global problem, and its impacts are noticeable at all levels of the environment and across various sectors. The previous chapters have reviewed the emerging risks associated with climate change scenarios on buildings and real estate in terms of physical and operational emerging risks. Moreover, these risks on buildings and real estate have been highlighted as incurring costs from an economic perspective, as well as in regard to other emerging economic risks on buildings, such as their value. From the perspective of economic risks impacting buildings and real estate, the public sector, i.e. governments and the private sector, such as insurance companies, also will be affected. According to DECCAN Chronicle (2012), as a consequence of CCS, the economic growth of the world will be reduced by around 3.2% of the gross domestic product by the end of 2030.

This part will discuss and identify the financial risks emerging as a result of CCP on the buildings and real estate.

6.2 The Concept of Financial Risk

Generally, the term 'risk' is understood to mean to *'expose something valued to danger, harm or loss'* (Stevenson, 2010); however, according to Twigger-ross and Orr (2012) risk, in the building sector, the term is used to refer to *'combines the likelihood an event will occur with the magnitude of its outcome'*. Consequently, from a buildings perspective, risk can be defined as all threats occurring on buildings and their elements due to the effect of climate change scenarios.

According to Twigger-ross and Orr (2012), who provide a critical explanation of the financial risks in the building sector, the risks and threats to buildings as a result of climate change scenarios lead to damage in buildings and real estate, which result in financial losses; these can be measured from an economic perspective by evaluating the costs of the damages.

In this research project, the emerging financial risks will be used to refer to all economic risks impacting the buildings and real estate sectors, resulting in greater economic losses on the building sector and other associated sectors. These include direct and indirect emerging risks, such as a reduction of the value of property and insurance problems, respectively.

6.3 The Cost of Climate Change Scenarios

Climate change is an ongoing issue for the entire world across all sectors, including businesses, governments and societies. These continuous climatic changes will lead to changes in the policies, which will induce a variety of economic issues in such sectors and will result in different sets of economic risk (Symon, 2013; Fankhauser and Tol, 1996). Moreover, different climate change scenarios affect economic activities in many sectors and buildings in particular; this will lead to unexpected costs due to such climatic conditions (Ackerman and Stanton, 2006). According to House of Lords (2005), cited by Rt Hon (2005), the climate change patterns are considered to be an issue for the ministries concerned with the environment and energy; however, it has also become an important issue for the finance and economy ministries. Moreover, from a buildings perspective, changes in policies due to the risks of climate change patterns on the building sector could affect investments of buildings and real estate in the near term. This effect will create risks and disruptions surrounding economic investment in the buildings sector, such as through reducing the value of property and their performance (Szyman and McNamara, 2008). Additionally, the building sector has been affected by the situation and level of the economy; however, the economic tools and incentives in the building sector play an important role in assisting and encouraging investment in the sector. These economic instruments are a crucial issue for stakeholders (Huovila *et al*., 2007), meaning that the pace and magnitude of the risks emerging from climate change on buildings and real estate will increase the threat of the economic investment in this field, although the buildings and real estate located under the threat of such emerging risks will result in disruption across business activities.

According to Twigger-ross and Orr (2012), climate change scenarios constitute a threat to the economy as the business deals with patterns of climate change on a daily basis, which is considered a key challenge for businesses. The frequency and duration of the risks emerging from climate change patterns are a source of concern and fear across economic activities; floods are the most important threat affecting economic work. The economic risks of CCS on buildings and real estate could also range amongst the factors listed below:

- Damages to fixed assets, stocks and infrastructure.
- Delay the works, projects and loss of continuity.
- Insurance claims and reduce the value of the mortgage, especially in the affected areas.
- Increased costs for energy consumption.

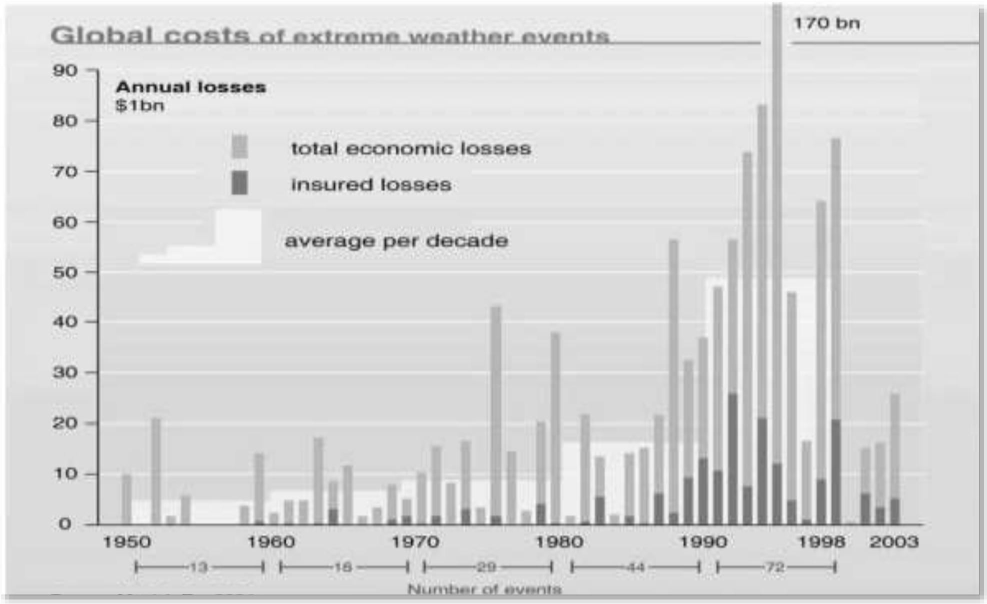

Figure 6-1 The Climate Change Cost Related to the Economic Losses Level; Source: Wilby (2007) pp.32

At present, according to Mountain *et al.*, (2010), the economic losses stemming from the impacts of climate change patterns are approximately £100 billion per year, with half of this amount loss occurring in industrial countries. For instance, Grossman (2012) demonstrates through reference to other works, such as Hoppe and Low (2011), that economic losses due to the disasters of climate change scenarios including extreme climate events, such as sea level rises, storms and flood, exceed £130 billion. In addition, the Figure 6-1 above provides insight into the high extrusive in annual economic losses, with the number of climate change events, where the increase in the climate change patterns risks will lead to more harm to the economic conditions, including economic losses. In addition, extreme weather events incur huge cost losses in the economies of countries, such as in Australia between 1967 and 1999, where the financial losses due to floods, hurricanes and strong storms amounted to more than £15 billion, which accounted for approximately 75% of the total financial losses due to natural disasters during this period (Department of Climate Change-DCC, 2009).

6.4 Emerging Financial Risks

There has been much evolution witnessed in the construction industry, as well as in terms of its affiliate technology, including buildings and infrastructure; however, the losses in the building sector are increasingly on the rise due to the impacts of various patterns of climate change, such as the changing temperatures and extreme events, including flood. In addition, the evidence became clear regarding the level of loss due to such climatic scenarios, which also resulted in greater emerging economic risks, especially in the building sector (Berz, 1997). It is predicted that many sectors will be affected economically due to changes in temperature, which will increase the possibility and severity of flood, and the extreme events of climate change, resulting in different levels of economic problems (Midgley *et al.*, 2005). Furthermore, the dramatic increases in severity and the frequency of extreme events of climate change scenarios will be owing to the changes in the temperature of the sea's surface, thus resulting in more damage and risk (Solomon *et al.*, 2007). According to London Climate Change Partnership (LCCP, 2013), the changes of temperature and extreme climate events, including flooding, is considered the key threat to the economy and business activities. Furthermore, most economic and social losses in the building sector come as consequences of various changes in the frequency and severity of the several climate change scenarios, such as temperature changes and flooding, along with extreme climate change events (Steenbergen *et al.*, 2012).

Based on these, the next part of this chapter will divide emerging financial risks from climate change scenarios on buildings and real estate into two clusters: the first is the emerging financial risks inflicted upon buildings and real estate as caused by changing temperatures; the second group is the emerging financial risks induced upon property as a result of flood and extreme climate change events, such as strong storms and flooding.

6.4.1 Emerging Financial Risks from Changing Temperature

Heat waves in the workplace lead to greater risks facing businesses, especially in terms of their profitability; these impact employees' productivity and increase the consumption of energy, whether for cooling or heating, in order to create a comfortable place of work, but which result in greater losses (CCRA, 2012). Moreover, due to the impacts of the climate change scenarios and heat waves—particularly on people—employers may experience losses. This can be seen in the example of July 2006, when organisations operating within the UK lost almost £840 million per week because of inadequate productivity amongst staff owing to the effects of increased temperature during that period (Roberts, 2008).

Furthermore, according to Capon and Oakley (2012), the Centre for Economics and Business Research study (CEBR, 2003) claims that the thermal comfort in the work environment is very important; this affects productivity, which in turn impacts the increase of financial loss. Productivity declines by approximately 8% when the temperature is 26°C; the losses in this situation amount to approximately £35 million, whereas increases in this percentage may reach 29% at a temperature estimated to be around 32°C; this will lead to losses of approximately £126 million. Employees lose more than half of their production at 38°C, which is estimated as resulting in approximately 62%; financial losses will be around £270 million. In addition, by the year 2050—as a result of high temperatures—the use of energy, especially for air-cooling purposes, is expected to increase by around 10–16%, thus leading to increases in the economic pressure on countries (Glynn, 2005). These risks from changing temperature, impacting employees' productivity and increased energy demands, will result in reduced profit margins—especially for employers and companies. Therefore, buildings and real estate that are unable to cope with the changes in temperature and provide a comfortable environment for their employee will lead to greater financial losses.

Increased temperature will lead to restricted access and road usage due to erosion, and increased landslip, which will result in more affected areas (Tubb *et al.,* 2003). Furthermore, changes in temperature, along with the level of proportion of rainfall, will cause the frequency of drought and soil moisture, subsequently resulting in increases of soil heave and contraction, which induce structural damage upon buildings and real estate, such as in the form of cracks, which might be very costly to repair. It is predicted that the changes in temperature level are likely to increase these areas, thus leading to augmenting the problem of soil moisture (Vivian *et al*., 2005; Graves and Phillipson, 2000). Furthermore, clay soil is considered to be the most important factor in the process of construction for new buildings, as well as the first factor responsible for the safety of the building in existing premises. In particularly, the clay soil is vulnerable to heaving and shrinkage based on the level of humidity, which is affected by temperature changes (Gill *et al.*, 2004). This increase in areas, which is prone to soil heave and shrinkage, will lead to greater financial losses and the limitation on available lands and areas suitable for building and construction projects. As a result, this will limit the development processes and will identify areas depending on the quality level of the soil, along with the events recorded, including structural problems and crack damages for buildings. This will, in turn, lead to a large disparity in the prices of land, area and real estate based on their existing areas. In addition, climate change results in the acceleration of the increase in economic losses in the world, which affects factors exacerbating economic losses, such as a high rate of population due to migration to stay away from the affected areas, increases in living standard costs, and a large concentration of population in urban areas, which increases the pressure on services and resources (Roaf *et al*., 2009).

Furthermore, as an illustration Figure 6-2, there are significant rises in the amount of financial losses incurred as a result of the emerging risks of soil heave and subsidence on buildings and real estate (Graves and Phillipson, 2000).

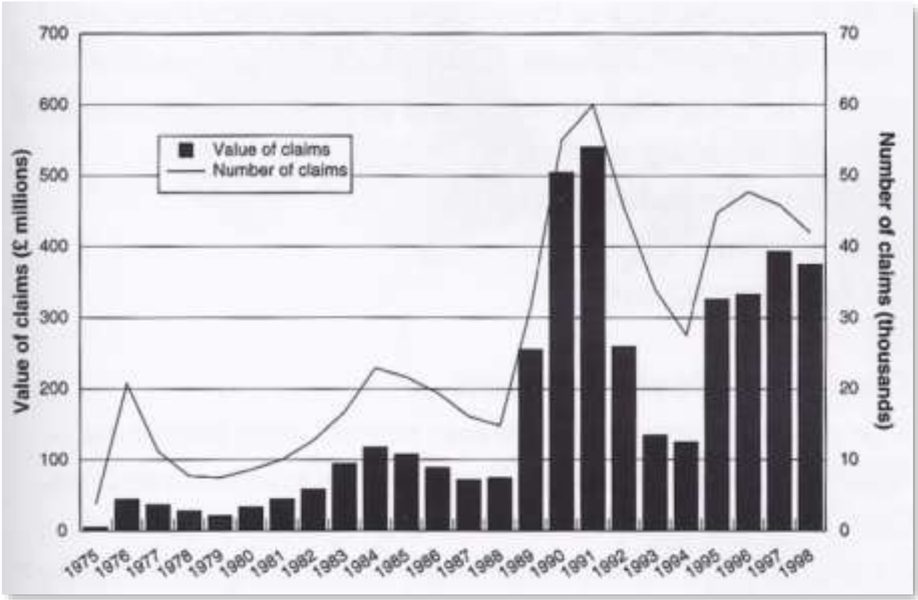

Figure 6-2 The Financial Losses due to Soil Condition; Source: Graves & Phillipson (2000) pp.9

According to Gill *et al.*, (2004), the risks of climate change patterns would affect the attractiveness of the areas and residential complexes, which will increase the prices of insurance based on the severity of such climatic risks, and would become impossible for low-income households, thus forcing companies and high-income families to move to safer areas and less costly insurance to increase profits and investment opportunities, safety, and ease of insurance. As a consequence of these emerging financial risks, a lack of consistency will be recognised across affected areas based on such factors, which include the availability of insurance and exposure to the risks of climate change scenarios, which will control the population type, leading to the emergence of poor communities and areas. The risks of climate change scenarios on lands and areas, affecting their stability, are recognised as the most crucial risk, as mentioned frequently by Local Planning Authorities (Tubb *et al.*, 2003).

6.4.2 Emerging Financial Risks from Flooding and Extreme Events

Increased frequency of climate change patterns, including flooding, more intense precipitation and storms, are projected to negatively affect the economy across many sectors. Financially, this will result in increased pressure on businesses by increasing damages and disruption as a result of different climate change threats (CCRA, 2012). Furthermore, the fact that extreme events of climate change scenarios can lead to the shut-down of approximately one-quarter of global supply chain matters, this will happen during the occurrence of such climatic disasters—not in the coming decades. For example, the recent floods in Thailand and earthquakes in Japan have had a notable impact in terms of quarterly profit, which encourages international insurance companies to sound the alarm and accordingly take immediate action regarding the economic risks of climate change scenarios (Wagner, 2012). According to Swiss Re (2013), 2013 was one of the most expensive years in terms of the amount of losses due to the risks of climate change patterns. In consequence, around £5 billion in insurance claims was issued just in the first half of the year due to flooding.

According to Garvin *et al.,* (1998), the impacts of extreme weather have much potential in terms of harming the economy, as illustrated below in regard to the emerging financial risks:

1. Delays and disruption to work due to climate hazards.
2. Damage to materials' use, with greater difficulties in their use, owing to increased site wastage.
3. Day loss due to the frequency of climate change and the number of unsuitable days for work, which affects site productivity.
4. Increased problems across plants, such as through the disruption of the use of the plant and more damages.

Such emerging financial risks from climate change scenarios can result in increases to the disruption of work progress through the effects on buildings and real estate, especially in business, with reductions in their growth and profits; this will lead to more financial burden and greater losses.

Based on Vivian *et al.,* (2005), with reference to Ellis and Thomas (2002), in the USA, for example, the impacts of climate change scenarios are recognised as the fourth reason for delays in the construction of highway. Moreover, sudden changes in climatic patterns, crashes and hangs outdoor works, such as in the construction industry, result in an increased duration of projects, as well as further delays in delivery. This also leads to increases in associated costs, thus meaning additional economic losses (Graves and Phillipson, 2000).

In addition, owing to extreme climate events, especially in terms of increased precipitation and strong storms, which lead to flooding, business activities are more vulnerable to disruptions and delays owing to the emerging risks on buildings and real estate. This has a negative effect on public and private organisations, as well as all other sectors, such as through increases in the annual insurance payments, which will hurt income and financial plans as a result. Owing to the increased possibilities and expectations of damages due to climate change risks, it has become difficult to find an insurance company; if one is found, the prices will be much more expensive (CCRA, 2012). Importantly, this will affect insurance availability and accordingly will lead to greater financial risks, such as losses, greater economic pressure and decreased profit. These emerging financial risks will incurred at both levels across the individual and private sector, such as in terms of business, as described.

The insurance sector is already engaged with the emerging financial risks of climate change scenarios, which affect most other sectors and result negatively in impacts across the insurance sector (Berz, 1997; Tubb *et al.*, 2003). From an insurance perspective, the extreme climate circumstances, such as in terms of sea level rises and strong storms, will increase damages being inflicted upon insurance companies, such as through paying the insurance cover for the affected buildings and real estate. Such financial risks lead to increases in the pressure on insurance companies, and further push them to bear heavy losses or to increase prices significantly, or otherwise to withdraw from the insurance market (Repetto, 2012). Furthermore, as a result of climate change disasters the average annual insured losses increased from approximately £0.5 billion in the 1960s to around £6 billion in the 1990s, where the average increase is approximately half a billion each year (Roaf *et al*., 2009). The insurance industry is facing growing concerns of climate change—especially floods and storms—which increase financial losses: for example, in the UK, average losses are approximately £700 million per year; this amount could rise up to £2 billion in a bad year, such as that which occurred in 1990 (Garvin *et al*., 1998).

Year	2010	2020	2030	2040	2050	2060
Expected Annual Loss	1.1	3.3	9.1	24.3	61.8	153.2

Table 6.1 Expected Annual Losses from Extreme Climate Events by £ Billions; Modified from Repetto (2012).

In addition, the financial risks emerging from climate change patterns are increasing dramatically, as illustrated in the Table 6.1 above, with the expected amount of losses during 2010–2060 due to extreme climate vents resulting from climate change scenarios (Repetto, 2012). This means that the various emerging effects and risks on buildings and real estate from climate change patterns will lead to indirect risks on organisations and companies with regard to insurance and insurance availability to their property, along with the negative impacts on insurance companies: for example, Table 6.2 presents the expected insurance claims in the UK, which are highly expected to increase by three-fold due to different climate change scenarios (Dlugolecki, 2004).

Climate change scenarios	2004		2050	
	Annual average	Extreme year	Annual average	Extreme year
Subsidence	300	600	600	1200
Storm	400	2500	800	7500
Flooding	400	1500-5000	800	4500-40000

Table 6.2 The Annual Average Insurance Claims (£ million) due to CCS Risks in UK; Adopted from Dlugolecki (2004).

Based on many studies, such as those by Berz (1997), LCCP (2002), Wilby (2007) and Twigger-ross and Orr (2012) the following factors are recognised as additional financial risks emerging from climate change patterns on buildings and real estate:

- New extreme values in certain regions
- Increased exposure to more insurance claims for insurance companies.
- Increased cost and difficulty of obtaining flood insurance cover in both level household and business.
- Insurance claims and reduce the value of the mortgage, especially in the affected areas.
- Greater claims potential
- Poorer claims experience
- Lagging premium adjustment
- Rising demand for insurance cover of natural hazards.

The increases in the severity of climate change scenarios will lead to rises in the possibility of flood, which in turn increases the likelihood of damage to buildings and real estate. Thus, the emerging economic risks on property will increase, such as through rising insurance premiums, difficulties in obtaining insurance, and increased insurance prices. Therefore, due to such financial risks, both individuals and the private sector will face difficulties in finding and securing mortgages (CCRA, 2012). These areas, buildings and real estate would be away from the business market and become less attractive to live, work, and invest due to the threat of flood risk (Gill, 2004) and other climate change patterns. Reputation of such areas and real estate could also be impacted as a result of their vulnerability to the risks of climate change patterns, such as flooding, and the ability to obtain insurance. These will result in affecting the households and investors in such areas, and will negatively control the prices of real estate and buildings (LCCP, 2002). As a consequence, the cost and premiums of insurance in such areas, for both buildings and real estate, will be dramatically increased.

Berz and Loster (2001), as cited in Gill (2004), note that, in the affected areas, the rate of risk might be too high, which would increase the damages of climate change risks on property, resulting negatively on insurance companies, policyholders and buildings in such areas. This can be seen when considering the following financial risks, sequentially:

- Companies lose the affordability to insurance coverage in the affected areas, leading to loss competition in the market,
- Higher insurance rates and premiums,
- Buildings and real estate become uninsurable due to the damages of climate change scenarios or increase the proportion of exposure to such risks in the future.

From business perspective, emerging financial risks arise from the impacts of climate change scenarios, which limit economic growth due to dwindling investment opportunities and weaknesses in profit ratios due to different climatic hazards on buildings and real estate. This will lead to more emerging financial risks, as shown below, which are rising with the increasing probability of the occurrence of extreme events of climate change:

- An increase in internal and administrative expenses especially in insurance process,
- Reduction of employment opportunities in the affected sectors,
- Weakness of the incomes from investment leading to an increase the failure to achieve equity growth,
- Increased insurance premiums,
- Withdraw insurance or reduce the limits of insurance cover (LCCP, 2002).

In addition, the report prepared by Land Use Consultants in association with other organisations (2006) illustrates more of the emerging financial risks resulting from climate change patterns:

- Failure to meet consumer expectation.
- Disruption to supply chains and productivity.
- Financial and operational problems selling or letting and higher management costs.
- Insurance cover problems due to increased risk of subsidence in areas with clay soils.
- Higher costs and potential problems of insurance due to flood damages to buildings and real estate.

According to Dailey *et al.,* (2005), the level of financial risks is based on both factor location and the condition of the markets, even in the business or building sector. These factors will affect several economy-related factors, including administrative and operational expenses, along with associated taxes and the recognised exceptional financial risks. In addition, in the building sector, the extreme events of climate change scenarios affecting the construction process, such as delay in the supply of materials or in construction work, will result in the potential delay, delivery and operation of the project, which will ultimately increase financial losses, including overheads and financing (Szyman and McNamara, 2008). Moreover, increasing threats of flooding risk on buildings and real estate means stakeholders are less able to renew their property insurance, resulting in further losses and increases in the probability of invalidating their mortgage (LCCP, 2002). For instance, in the UK, insurance companies have the option of opting out from insuring any property when are located under the threats of climate change patterns (Graves and Phillipson, 2000).

These emerging financial risks—specifically those on buildings and real estate—will affect the value of property, as discussed above. According to the Community Resilience to Extreme Weather (CREW) project, it is expected that the value and prices of property will be affected based on the extent of exposure to the risk of flooding; this may adversely affect the stakeholders' equity in mortgages (Hallett, 2013). Accordingly, the probability of mortgage rejection might be increased due to the rise of vulnerability to the impacts of various climate change scenarios on such buildings and real estate (Graves and Phillipson, 2000). Furthermore, this will result in decreases in the ability to secure funding for refurbishment due to the negative valuation of the property or non-acceptance in the mortgage. The negative valuation of buildings and real estate might be due to their poor adaptation concerning the risks of climate change patterns.

Buildings designed are built in order to meet the criteria of resistance and adaptation of different climatic conditions; however, extreme events of climate change scenarios result in structural damage to buildings and cause extensive risks (Steenbergen *et al*., 2012). Buildings are recognised as a safety valve in the value of real estate investment. As climate change occurs, damages are inflicted to the structure of buildings and real estate, along with related services; therefore, areas vary based on the level of their attraction in terms of rents, value and the extent to which they can cope with the risks of climate change patterns. Buildings failing to deal with climate change risks or lacking ability to meet level standards set by stakeholders will be adversely affected in terms of their value and usability for sale or investment (Szyman and McNamara, 2008).

For example, the ability of buildings to cope with the risks of climate change scenarios will become more attractive for investment or households; however, buildings that are far from meeting the requirements of stakeholders may suffer severe decline in demand, which will affect their value. In order to restore such buildings and real estate in line with the competition, improvements and development may be required, which might prove costly and complicated in some cases. In such instances, buildings and real estate will be affected economically in terms of their value and performance (ibid). According to Tubb *et al.,* (2003), the risks of climate change patterns need to adopt more contingency plans, although this will lead to greater economic losses and decrease the profitability for both business and investment.

In the building sector, the economic incentives and instruments are recognised as a cornerstone of investment in this sector, where they are more effective than regulations and standards. Financially, for example, buildings utilising energy-saving methods are more attractive to stakeholders than normal buildings (Huovila *et al*., 2007). Additionally, other economic tools and incentives cannot be neglected, as these impact buildings economically, such as through tax rates and increased rates of profit from investment return (Huovila *et al*., 2007).

As additional financial risks from climate change scenarios, there will be disorders in revenue due to consumer behaviours. According to LCCP (2002), it is highly projected that the risks of climate change will alter customer attitudes; this would result in the demand of different consumer goods in different amounts, meaning companies need to address their customers' needs in order to avoid economic losses and problems (Grossman, 2012). Furthermore, strong winds and storms as a result of climate change impact the safety and comfort of goers of the recreation and public places, such as markets. They also negatively affect the tools and services that make the place more suitable for their requirements; this will encourage people to avoid such places due to bad experience. Consequently, greater economic losses will be faced, which might be severe—especially in investment and commercial buildings (Graves and Phillipson, 2000). For instance, according to Bigano *et al.,* (2008), the tourism industry is an important income source for most countries in the world, and climatic conditions play a very influential role in the industry: for example, climate change and its extreme events affect tourist areas' reputation owing to climate being an essential factor for tourists, as well as damage to heritage buildings and attractions.

In addition, due to many risks of climate change patterns on other sectors, including disruption transport, destroying infrastructure and affecting supply chain, the cost of other goods and products will increase and become more expensive. For example, across food suppliers, prices will increase when suitable land for agriculture is reduced, or products may be lost due to different climatic change risks (Tubb *et al.*, 2003). Thus, similarly, this will be the case of all other sectors and products, and will make the situation worst based on increases of vulnerability to climate change risks.

6.5 Summary of this Chapter

It is obvious that the financial risks emerging as a result of climate change scenarios can be linked to both first extreme climate events, such as floods and storms, leading to damage on property, and second, to the harmful environment, which may also be linked to daily weather, including high temperatures that affect employee productivity, for example, subsequently causing financial losses to organisations, companies and employers. In addition, Table 6.3 below summarised the main findings from literature review in this chapter.

Issues Learned from the Literature Review	Argumentations	Research Gaps	Research Questions
What are the financial risks that emerge from CCS?	As the literature review discussed in this chapter, the financial risks are that related to cost and economic situations in the building sector.	There is a need to clarify the financial risks that occur as a consequences of CCS	How to identify the emerging financial risks?
Are there differences between cost of CCS and the emerging financial risks?	As discussed in this chapter, there is an overlapping between cost of the risks from CCS and the emerging financial risks	There is a need to clarify the companion between the cost of CCR and the financial risks.	What are the costs of CCR that have to be involved in financial risks?
Is the emergence of financial risks dependent on other risks or not?	As per the literature re-view discussed in this chapter, the financial risks may not independent in reality as their emergence based on appearance of other CCR on buildings.	There is a need to investigate the related financial risks the occur on the building sector from CCS?	What is the suitable way to identify the financial emerging risks and their occurrence time scale?

Table 6.3 The Issues Learned from the Literature of Financial Risks

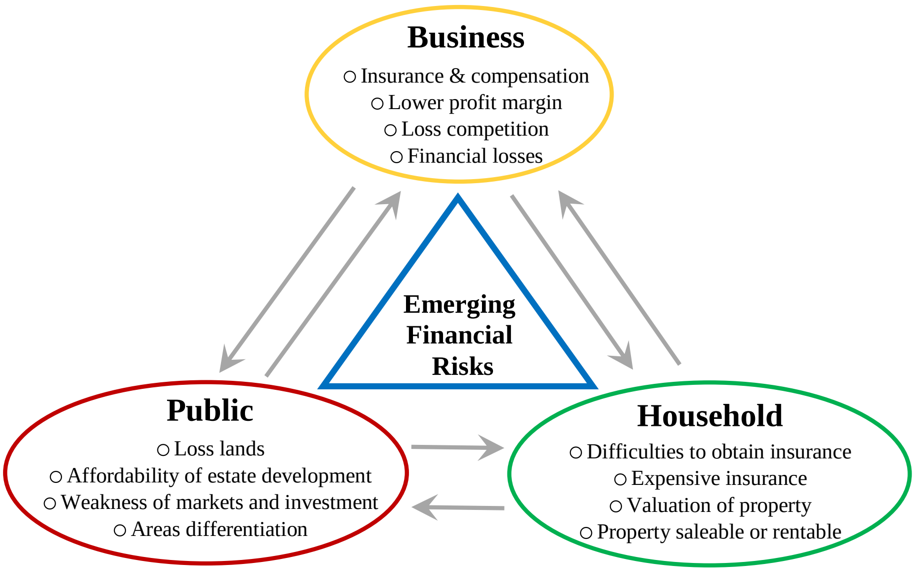

Figure 6-3 The Significant Emerging Financial Risks of CCS on Buildings and Real Estate.

Furthermore, as can be seen from the above discussion, it can be stated that the essential emerging financial risks on buildings and real estate, resulting from climate change patterns, may be divided into three groups, as illustrated in Figure 6-3 above. Moreover, the full identified emerging financial risks are summarised in Table 6.4 below.

		Emerging Risks identified	Reference
Financial Risks	**1**	Increased insurance excess	Repetto (2012)
	2	Additional expense in insuring buildings prone to the urban heat island effect	Gill *et al.*, (2004); Tubb *et al.*, (2003)
	3	Additional expense in insuring buildings in flood risk zones	Repetto (2012); CCRA (2012)
	4	Increases in areas prone to soil heave/shrinkage	Vivian *et al.*, (2005); Gill *et al.*, (2004); Tubb *et al.*, (2003)
	5	Un-insurability due to climate change	LCCP (2002); Graves & Phillipson (2000)
	6	Affordability of property insurance	Gill *et al.*, (2004); LCCP (2002)
	7	Availability of property insurance	CCRA (2012); Tubb *et al.*, (2003)
	8	Lower profit margins	CCRA (2012); Glynn (2005)
	9	Unable to repay debts	Tubb *et al.*, (2003)
	10	Equity growth not realised	Gill *et al* (2004); LCCP (2002)
	11	Increase in administrative expenses	ABI (2005); Gill *et al.*, (2004)
	12	Reduced ability to secure funding for refurbishment due to negative property valuation	Graves & Phillipson (2000)
	13	Reduced ability to secure funding for adaptation due to negative property valuation	Graves & Phillipson (2000)
	14	Fall in value of mal-adapted properties	Hallett (2013)
	15	Loss of income from properties	Szyman & McNamara (2008); Huovila *et al.*, (2007)
	16	Businesses become less competitive	Gill et al (2004)
	17	Properties may not be saleable because of climate change compliance	Szyman & McNamara (2008); Huovila *et al.*, (2007)
	18	Negative property valuation due to structural damage	Hallett (2013); Szyman & McNamara (2008)
	19	Negative property valuation due to services damage or compliance with climate change legislation	Hallett (2013); Szyman & McNamara (2008)
	20	Loss of revenue due to customer behaviour	Bigano *et al.*, (2008); LCCP (2002); Graves & Phillipson (2000)
	21	Changing patterns of consumer demand	Grossman (2012); LCCP (2002)
	22	Affordability of property rent/development	Szyman & McNamara (2008)
	23	Increase costs to purchase	Tubb *et al.*, (2003)

Table 6.4 The List of Identified Emerging Financial Risks

CHAPTER 7: OCCUPANT DISSATISFACTION EMERGING RISKS

7.1 Introduction

Buildings and real estate are designed and built to protect occupants living or work within buildings, safeguarding them from the impacts of different climatic conditions and creating a comfortable environment for them inside the property (Pretlove and Oreszczyn, 1998). Nevertheless, climate change scenarios will have an impact on buildings and will accordingly reduce their life span, which will negatively reflect on the buildings' occupants—whether residential or commercial buildings. According to Hacker *et al.,* (2005), the risks of climate change on buildings would affect the indoor environment, such as through changes in temperature and humidity, which is known as an indirect risk. In addition, the daily lives of occupants within buildings and real estate, in terms of employment and livelihoods, will be affected by these risks (Prats *et al*., 2011).

This chapter of research will start by illustrating post-occupancy evaluation satisfaction in order to identify the risks emerging from climate change scenarios on occupants.

7.2 Satisfaction of the Post Occupancy Evaluation

Under the threat of climate change scenarios, risks on buildings and real estate, the occupants will be exposed to the results of risks on buildings, especially the effected property. Buildings designed for occupancy, as well as their individual elements and facilities, all need to meet their occupants' needs and requirements (Khalil and Husin, 2009), thus leading to achieving their satisfaction with the place; therefore, post-occupancy evaluation will lead to establishing the criteria to evaluate the extent of buildings' occupants' satisfaction with their buildings—whether homes or work places.

7.2.1 Definition of Post Occupancy Evaluation (POE)

Post-occupancy evaluation is not a new technique; it was afforded some attention between the 1960s and 1970s, during which time there was much emphasis directed towards the requirements of buildings' occupants (Voordt *et al*., 2012). The notion of post-occupancy evaluation has been explained by Khalil and Husin (2009) as a prominent tool to indicate the extent to which occupants are safe, satisfied and comfortable with their buildings, leading to identifying the indoor environment and its problems and risks from surrounding changes, such as climate change patterns. It is also known as the actual process, which compares the performance of buildings in terms of the needs and requirements of the occupants, such as facilities, safety and thermal comfort (Cooper *et al.*, 1991). According to Voordt *et al.*, (2012), the POE can be defined as *'a tool that is being used to investigate users' experiences (satisfaction, perceptions and preferences) and user behaviour in connection to the built environment'*. Moreover, Vischer (2001) describes the post-occupancy evaluation as '*any and all activities that originate out of an interest in learning how a building performs once it is built, including if and how well it has met expectations and how satisfied building users are with the environment that has been created'*. In other words, the POE is a process involving establishing the extent of the relationship between occupied buildings and their occupants, as well as how satisfied they are with the environment of the buildings and their facilities in different circumstances, such as climate change scenarios in particular. Moreover, it is an important technique for the building sector in terms of the occupants, builders and operating organisations, as it assists in establishing the potential risks that threaten the comfortability and safety within buildings and real estate, and related to occupants.

7.2.2 Importance of Post Occupancy Evaluation (POE)

According to Marans (1984), as cited in Abbaszadeh *et al.*, (2006), for several decades, the POE has been adopted in order to evaluate buildings' occupants' levels of satisfaction. Furthermore, POE helps to determine the emerging risks within the environment of buildings and real estate, which show a correlation with the occupants' requirements, such as in terms of safety, comfort and satisfaction (Voordt *et al*., 2012). Additionally, the POE is necessary and essential, particularly in line with sustainable buildings, across all phases of the buildings, ranging from axiomatic design stage, the construction process and operation phase (Meir *et al*., 2009), helping to determine the effective performance and operation of buildings, along with the satisfaction and comfort of buildings' occupants (Nawawi and Khalil, 2008). Furthermore, POE is recognised as a powerful technique to appraise the actual value of the buildings and their facilities, and allows owners to determine the outcomes in terms of economic, environment and occupant (Michigan State University, 2008). According to the British Council for Office (BCO, 2007) as cited in Riley *et al.*, (2009), the main reason behind adopting POE is to confirm the performance of the building's functions, especially in mind of the requirements and needs of occupants. These can be limited through the following list:

- Discovering whether buildings provide and support the needs of occupants.
- Identifying the problems and risks in the building, namely those that influence occupants.
- Improving the performance of the building by providing a suitable environment, which positively reflects on the performance of the occupants.
- Increasing the interaction between occupants and their buildings by taking into account their thoughts and aspirations.

In addition, the Sustainable Construction and Innovation-SCI-Network report (2012) states that the POE is critical to achieving the following targets:

- Ensuring the continuance of occupier productivity and the resource efficiency within buildings.
- Informing improved capital investment decisions for refurbishment works and new buildings, thus maximising entire life value and reducing carbon emissions across the organisation.
- Ensuring investment is defined by assessed user ‘needs’ rather than perceived ‘wants’.
- Improving the predictable performance in terms of the design, construction and operation of sustainable buildings.

These factors and determinants of POE help buildings and real estate to perform in line with their design and operating role in different conditions of climate change patterns. Also, establishing ways and means of dealing with the potential risks emerging from climate change scenarios, all of which directly affect occupants through the influence on interior atmosphere of the buildings and real estate, as well as their facilities, is paramount.

Raj *et al.,* (2011), conclude that the POE is very important and crucial to investigating both building users’ behaviours and evaluating the performance of buildings and real estate, especially by considering the risks emerging from climate change events and the impacts of decisions taken by occupants due to such risks, which will impact the surrounding environment. Moreover, one of the most important objectives of POE is finding out that the goals and needs of occupants are achieved, along with the correlation between buildings’ facilities and occupants’ satisfaction (Mallory-Hill *et al*., 2004).

The Michigan State University (2008) clustered the advantages of the POE into three groups, as illustrated in Table 7.1 below.

The advantages of post occupancy evaluation	Short-term benefits	Identify problems and solutions
		Proactive facility management responsive to building user values
		Improved space utilisation
		Improved attitude of building occupants through consider their thoughts
		Understanding of the performance implications of changes
		Better-informed design decision-making and understanding of the consequences
	Medium-term benefits	Built-in capacity for facility adaptation to organisational change and growth
		Significant cost savings
		Accountability for building performance
	Long-term benefits	improvements in building performance
		Improvement of design databases, standards, criteria, and guidance literature
		Improved measurement of building performance through quantification

Table 7.1 The Benefits of POE; Source: Michigan State University (2008).

It is clear that the post-occupancy evaluation is very important in the buildings sector, and depends mainly on two basic elements: the first is buildings' occupants through fulfilling their requirements and creating a comfortable atmosphere for them inside buildings, especially during periods of climate change events, including changing temperatures; the second element is measuring the performance of the buildings and real estate in terms of performing their design and operational duties in different climate change patterns, such as floods, storms and heavy precipitation. These lead to achieving the satisfaction of occupants and increasing their productivity, which will result in the success of buildings and real estate.

It could be suggest that there is other value associated with the POE through monitoring the operation of buildings; this will facilitate the early detection of risks emerging from climate change, leading to quick processing or repair. Implementing this monitoring will aid in the avoidance of any effects or risks from CCS on the continuation of buildings' usage, as well as on their occupants.

7.2.3 Factors of Post Occupancy Evaluation (POE)

According to Cooper *et al*., (1991) and Raj *et al.*, (2011), cited Preiser *et al.*, (1988), the results of the POE are achieved by considering three categories of factor, all of which have an impact on the performance of buildings and real estate; these are technical, the function of property and the behaviour of occupants. This method was agreed and supported by most of the publications in the field of post-occupancy evaluations (Cooper *et al*., 1991). In addition, Voordt *et al.,* (2012), state that the POE, in the present time, is used to investigate the values of facility, performance and workplace management and sustainability, as well as the tools of occupants' satisfaction, such as requirements, aspirations and preferences. Furthermore, the comprehensive POE should include the evaluation of productivity and well-being of buildings' occupants. In terms of assessment, the performance of the buildings in relation to operation and function (Abbaszadeh *et al*., 2006) are also considered. In the study conducted by Raj *et al.,* (2011), the POE factors were clustered into three groups: the first is the technical category including the quality of the indoor environment and the control system of the building; the second group comprises the functional role of the POE, which focuses on the success of buildings through measuring the extent of the performance of the building in relation to its intended function and design; and lastly, the third cluster centres on the behaviour of the POE, which considers the buildings' occupants behaviours with the building and its facility.

According to Preiser (1995), as cited in Riley *et al.,* (2009), a range of possible effect factors on buildings' occupant can be identified, as shown below:

- Health and safety problems.
- Accessibility problems.
- Poor air circulation and temperature control.
- Poor signage and difficulties in finding route such as (emergency exit).
- Security problems and lack of storage.
- Aesthetic problems such as the façades and external facilities.

Moreover, Khalil and Husin (2009), as established through their study findings, the most important factors of post-occupancy evaluation, in terms of the comfort of buildings' occupants, are the level of visual comfort, indoor air movement and thermal comfort.

On the whole, many studies carried out in this domain (Abbaszadeh *et al*., 2006; Meir *et al*., 2009; Raj *et al*., 2011; Choi *et al*., 2012) consider the factors that will have an impact on occupants in terms of their comfort and productivity as the key post-occupancy evaluation factors. Most of these POE factors occur as a consequence of the risks emerging from climate change scenarios on buildings and real estate, such as the indoor environment, including the level of humidity and changing temperatures.

Figure 7-1 below illustrates the correlation between climate change patterns and the factors of post-occupancy evaluation: for example, changing temperatures and heat waves are consequences of climate change, and both have a direct impact on several POE factors, including the indoor environment and health problems; that will result on the occupant dissatisfaction. This relationship will assist to uncover the emerging risks from CCS on occupant dissatisfaction within buildings and real estate.

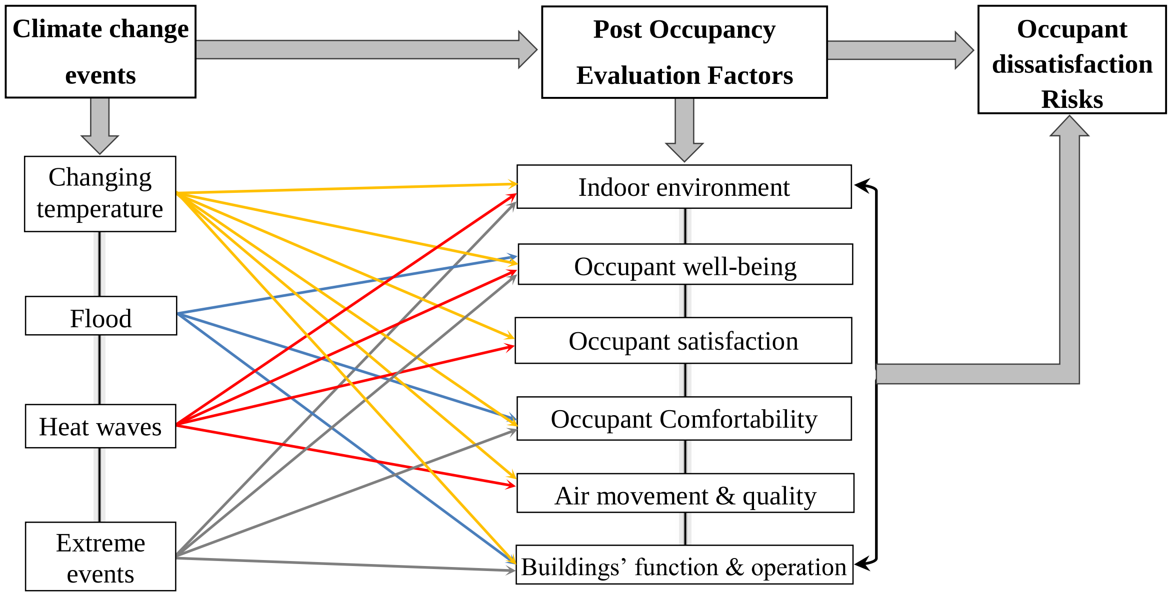

Figure 7-1 The Relationship Between Climate Change Scenarios and POE Main Factors

7.3 Emerging Risks on Buildings and Real Estate Occupants

Built on the above clarification of the post-occupancy evaluation, the related risks emerging from climate change scenarios will be identified. The climatic risks affecting buildings and real estate in terms of effecting occupants, such as through disrupting comfort and safety, as well as damage to the property themselves, such as in terms of the usability of their elements and facilities, are recognised as factors in leading to the dissatisfaction of the occupant as a consequence of emerging risks. These emerging risks can be divided into two groups of risk stemming from CCS: the first involves the direct risks occurring from the occupants of the buildings' environment; and second cluster involves indirect risks on buildings and are related to the occupants.

7.3.1 Risks on Indoor Environment

The impacts inflicted upon buildings and real estate, as a result of climate change scenarios, may be diverse, and can impact the environment surrounding the property; this would inflict health problems upon occupants (Garvin *et al.*, 1998). Humankind is currently facing climate change risks, which are recognised as the key challenges affecting their lives in specific areas, such as human health and wellbeing, and the environment (De Wilde and Coley, 2012). Indoor air quality (including changes in the level of temperature) of the buildings and real estate are essential considerations for both building management and occupants, with changes needing to be made in these domains (Seppanen *et al*., 2004; Leaman and Bordass, 2005). These risks on the building's atmosphere will disrupt occupants' comfort, such as in terms of thermal discomfort, risk on their health and safety, and reductions in productivity. These types of emerging risk affecting occupants are considered consequences of the risks of climate change patterns on buildings and real estate, and their environment in particular.

The next part of this chapter will discuss these emerging risks in greater detail.

7.3.1.1 Thermal Risk

In the context of climate change scenarios, buildings will be exposed to the risks from these patterns, such as strong storms and wind, flood and extreme precipitation. These will affect buildings and real estate through heat and drought, which adversely affect the internal environment through controlling the indoor temperature, and the level of comfort (Roaf *et al*., 2009). This will be reflected through negative impacts, which are felt by the occupants of the property in several different aspects, including in terms of thermal comfort.

According to Gill *et al.*, (2004), cited Edholm (1978), in the early-20th Century—and owing to the development in building techniques, especially those related to improving indoor comfort conditions of buildings, such as through heating and cooling systems, for example—much attention has been directed to the thermal comfort of buildings' occupants. Furthermore, thermal comfort is recognised as an important and essential aspect in the built environment, and is pivotal in terms of achieving occupants' satisfaction (Roaf *et al*., 2009). Many researches were carried out in the 1980s, which claimed that there is a new generation of researchers asserting that the control of the internal environment of buildings will positively impact occupants' comfort levels, thus leading to fulfilling their satisfaction (Leaman and Bordass, 2005). Therefore, the internal environment of the buildings, including thermal levels, is an essential factor for occupants.

Buildings with low thermal capacity due to lightweight or poorly isolated features will create an uncomfortable atmosphere for occupants, where high temperatures in the summer time, as well as cold temperatures in the winter, are felt through the buildings (Roaf *et al*., 2009). Moreover, overheating occurs when the temperature is high inside the building, at which point the occupants will feel uncomfortable and anxious. Responses to the increases in temperature within buildings are different from one person to another, and ultimately depend on the level of internal heat. The effect of high temperatures on the occupants of buildings and real estate include feelings of discomfort, which subsequently affects productivity and performance at work, and can also result in illness and even death as a result of overheating (Capon and Oakley, 2012).

The risks of climate change scenarios on the internal environment of buildings are heavily concentrated in the direction of the impacts on the occupants of building, although the indoor environment can cause discomfort by controlling the level of internal temperature of property, which could be referred to as thermal discomfort. These risks to buildings' occupants may lead to other effects, which could be more important, and potentially risky and serious in some cases. These climate change risks are those risks commonly associated with the health of occupants in a building, which may occur due to strong disturbances in the level of heat due to climate change patterns or the inability of ventilation systems to provide a comfortable indoor atmosphere. According to Roaf *et al.,* (2009), the climatic condition might become warmer more so than before, thus resulting in extreme changes in temperature, which will affect the health of occupants within buildings and real estate. The warming of the climate will result in short-term health impacts, such as tropical diseases, which occur in occupants in heat wave conditions. Moreover, the extreme events of climate change, including storms and rainfall, will also impact occupants in a broader way and in different conditions (Ackerman and Stanton, 2006).

Garvin *et al.,* (1998), indicate that changes in the future climate conditions would have greater impacts on the internal atmosphere within buildings, which in turn will exacerbate the risks on occupants—particularly in terms of the health implications perspective due to an increase in the indoor pollution within buildings and real estate. This might include thermal changes and mould growth, which increase the level of discomfort and the possibility of health risks. Furthermore, changes in temperature within buildings—especially rises in temperature—will have an impact on occupants' health and can causes greater exposure to skin cancer, and may even result in death due to heat (Twigger-ross and Orr, 2012). These changes in the building's environment could also lead to more health risks and problems for the occupants, which might be more serious amongst certain populations, such as the elderly. According to Wilby (2007), increases in temperature will lead to reductions in air quality in buildings, which can cause disease, especially asthma, and may increase mortality rates due to thermal pressure. In addition, there are many perceived impacts on buildings' occupants due to thermal discomfort, which may be recognised as health symptoms, such as headaches and other health risks (Leaman and Bordass, 2005). Furthermore, rising temperatures threaten health, specifically the heart, and can increase the rate of sudden death, and the risks of heart disease and heart attacks. For example, based on an Australian study, which carried out an analysis on a group of people during the period 1996–2004, an increase in the rates of sudden death was experienced, equating to approximately 34%, in hotter summer months compared with winter months (Alarabiya, 2012).

7.3.1.2 Loss of Productivity

According to Capon and Oakley (2012), based on Thomas (1998), it has been noted that the internal temperature of buildings and real estate is very important in relation to occupants' comfort, which impacts their health and productivity at work. For instance, higher temperatures in the bedroom lead to discomfort and anxiety in sleep, subsequently resulting in poor performance at work; this situation worsens if the work environment is warmer and more uncomfortable. Moreover, indoor temperatures in the working place indirectly but negatively affect productivity from several aspects, the most prominent of which is the health risks and the level of occupants' satisfaction with the internal environment, including air quality (Seppanen *et al.*, 2004). For this reason, there is a strong correlation identifiable between the internal atmosphere of buildings—especially at thermal levels and in relation to the productivity of occupants. Many studies, such as that by Niemelä *et al.*, (2001), as cited in Seppanen *et al.*, (2004), demonstrate that the productivity of occupants reduces by around 2% for every degree Celsius in the event that the temperature exceeds 25^{o}C within buildings.

In addition, Figure 7-2 below describes the effects of high temperatures on occupants' productivity and the relationship between increases in indoor temperatures and reduced productivity. The worsening of this risk of increasing temperature and an increased poor situation of the internal environment of the place—both at work and home—negatively impacts the occupants of the place (Capon and Oakley, 2012). For instance, according to Land Use Consultants in association with various organisations (2006), in the UK, in circumstances of heat waves, such as that which occurred in July 2006, around £168 million was an estimated daily loss due to the reduction in staff productivity.

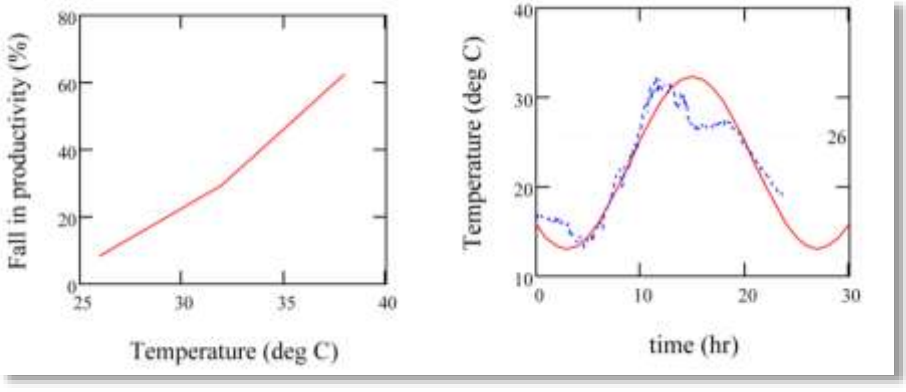

Figure 7-2 The Relationship Between Fall in Productivity and Internal Temperature;

Source: Capon & Oakley (2012) based on the examination of NIOSH (1986).

Bosello *et al.,* (2006), conclude that the risks of climate change patterns lead to a wide range of health problems being felt by occupants, thus resulting in reduced worker productivity, which might affect the economy. Additionally, according to EPA Report (1989), highlights that an estimated loss of £7 billion per year will occur due to the lost productivity of occupants, as well as additional costs for healthcare as a consequence; however, by improving the internal environment of buildings and real estate, such as in terms of air quality and thermal comfort, higher productivity will be achieved, along with reductions in the distraction of working days (EPA, 1997). Furthermore, through a study carried out by Holmes and Hacker (2007), it was found that, in well-performing buildings and real estate, namely those providing suitable and high-quality internal environments, increased productivity was achieved. In addition, according to McGregor *et al.,* (2007), there are numerous studies that have clarified the presence of a strong relationship between climate changes scenarios—especially hot weather—and psychological impacts, including increases in the level of crimes, street violence and riots. Moreover, many countries, such as the UK and the US, have recognised that most riots and crimes occur during the period of hot weather, such as summer time.

From an occupancy perspective, it is clear that temperatures rising inside buildings and real estate as a consequence of climate change scenarios play an essential role in affecting the occupants of property through physical harm, such as thermal discomfort, disease and death threats, or psychological harm, such as discomfort and disquiet from heat. All of these emerging risks are negative impacts on performance and productivity, in addition to behaviours with other members of society—even at work or at home. In addition, there are other effects related to occupants, such as the breakdown of devices due to greater heat and cooling system failures, all of which exacerbate these emerging risks.

7.3.2 Risks on Facilities of Buildings and Real Estate

Climate change patterns post a number of risks on buildings and real estate as consequences of climatic threats, such as extreme high temperatures, drier summers and strong precipitation. The potential risks on buildings as a result of such conditions are reducing the lifespan of operations, and are affecting buildings and real estate (Land Use Consultants, 2006). Moreover, the succession of the climate change scenarios risks on real estate result in increasing the frequency of their gravity on buildings, thus leading to the disruption of buildings' services and their facility. Consequently, this will affect the usability of property and could become impaired in terms of performance and function, going against the intentions of the design. For example, in London, the various risks associated with climate change scenarios, such as heat waves, floods and storms, affect the ability to respond to emergencies, leading to a disruption in services. This will be reflected through negative impacts on property, and their characteristics can become impaired (LCCP, 2002). In such circumstances, and with the severity of the risks of climate change on buildings and real estate, the usability of the property will be reduced, encouraging occupants to take any actions necessary to make their situations more suitable. Furthermore, in cases where buildings are unable to play their role in terms of the provision of services or the comfortable atmosphere of their occupants, occupants will implement their own actions in an effort to address the situation, which could result in the destruction of operational plans of buildings (Roaf *et al.*, 2009). With the recurrence of such situations, this may exacerbate the problem, with buildings becoming useless under the frequency of risks of climate change patterns, with the absence of radical rapid solutions to such risks. According to Leaman and Bordass (2005), risks emerging from climate change negatively affect the performance level of soundly operating buildings and real estate due to several factors, which most notably include the collapse or breakdown of operational equipment and inadequate maintenance processes. In addition to the negative effects associated with the actions of occupants, there may be breaches or the disabled operational strategies of buildings in response to climate risks.

Ultimately, it is expected that the outcome of buildings and real estate as a result of risks emerging from climate change patterns are failures in the performance of their intended design, which could result in reductions in functionality value. This will lead to impacts being experienced in terms of the continuity of the business in various ways. The report of London Climate Change Partnership (LCCP, 2002) points out that interruptions to business will occur as a result of the risks emerging from climate change scenarios, such as through the disturbance of infrastructure, including risks on roads and power lines, and telecommunications. According to Finch (2004), effective facility management depends on the provision of the needs of building occupants, and should seek to ensure the upper limit of facilities' performance as required, thus ensuring business continuity; however, risks of climate change scenarios, such as changes in temperature and reductions in air quality levels, may exacerbate the risk of deterioration in the working environment. This could result in reductions in the continuity of the business, through affecting the level of production of occupants or an impaired ability to attract staff owing to the serious deterioration of the place environment (LCCP, 2002).

Consequently, the occupants of buildings and real estate might take adverse actions, which would be more serious than the expectation of buildings' managers. These include leaving work, or litigation and complaints due to uncomfortable environment conditions in buildings.

According to Land Use Consultants in association with various organisations (2006), one of the possible risks associated with buildings' occupants is litigation against those responsible and in-charge managers or organisations due to the failure to take into account the risks emerging from climate change scenarios. Moreover, the lack of information detailing the extent of exposure to potential risks emerging from climate change on buildings will lead to litigation by the occupants as a result of discomfort within the internal environment of the buildings—especially during periods of hot weather conditions (Roaf *et al.*, 2009). According to Roodman and Lenssen (1995), estimated that approximately 30% of new and renewed buildings and real estate are suffering from the risks emerging from climate change patterns, including reduced air quality, thus resulting in occupant impacts. This is a high percentage of the number of buildings, which may prove to be hazardous to their occupants. As a result, such risks on occupants can result in increased occupant litigation due to poor environment exposure within the affected buildings (Clark, 2003), especially in work places. Furthermore, occupant litigation is a comparatively new phenomenon; however, there was a noticeable increase on this action against the potential risks emerging from climate change scenarios (Lord *et al.*, 2012). For example, in the US, organisations have adopted various measures and proactive steps in order to change their policy and strategies for assessing the risks emerging from climate change patterns, which are an effort to avoid the risk of litigation in cases of building failures to perform their designed and intended roles due to the risks emerging from climate change scenarios. On the other hand, however, such actions have been taken in order to strengthen the position of defence in regard to possible litigation (Dowden, 2005).

In this case, it could be suggest that potential occupant litigation is one of the risks emerging from climate change patterns in relation to buildings' owners or managers in particular, where occupants may resort to litigation owing to the failures mentioned above. This could also result in impacts being felt in terms of business continuity, as well as concerning the reputation of buildings and real estate due to the effects of the risks emerging from climate change patterns, all of which impact the facilities and usability of property.

7.4 Summary of this Chapter

It is clear that the risks of climate change scenarios affect the elements of the POE, which are considered as the main drivers for the comfort of occupants within buildings and real estate. This correlation between risks emerging from climate change patterns and the POE are related to several risks, which adversely affect the comfort and safety of occupants, as shown in Figure 7-3 below.

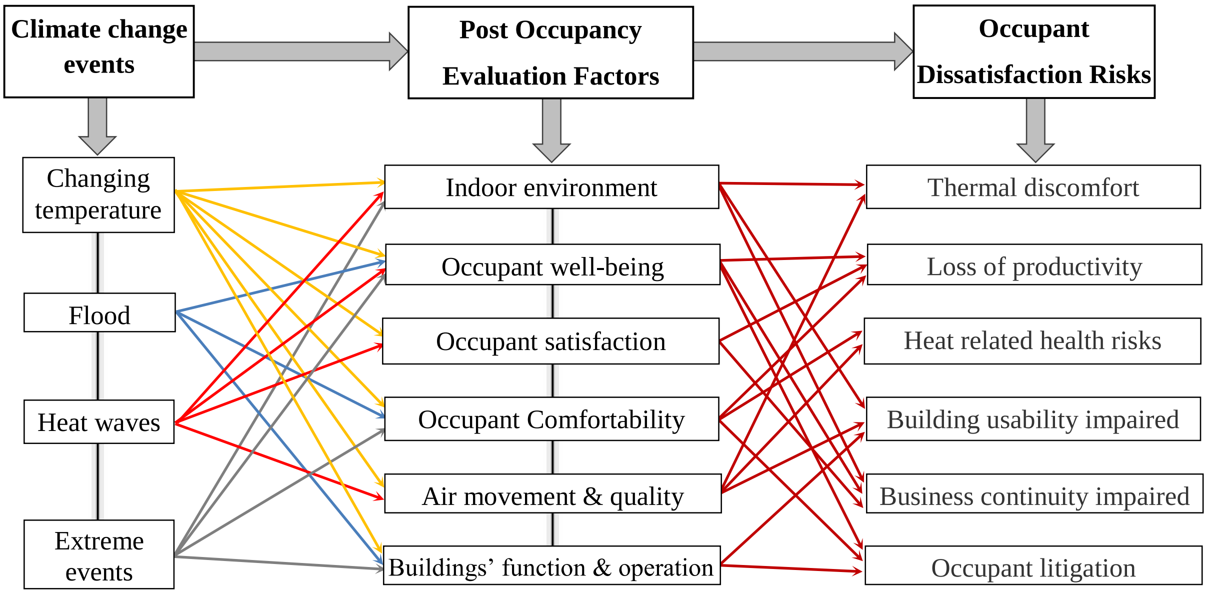

Figure 7-3 The Occupant Dissatisfaction Factor as a Consequence of CCR on POE

Furthermore, it is widely accepted that the internal environment of buildings and real estate is an important element for their occupants, as well as for those in charge of the management or maintenance of such property. It can be considered that the indoor comfort and convenient environment of buildings are an umbrella, which include all factors leading to achieving the comfort and safety of occupants.

Such factors include thermal comfort, the availability of safety and protection tools, and good air quality. All of these factors achieve the increased productivity of occupants and gain their satisfaction, which is recognised as one of the most important aspirations of buildings' owners and managers as reaching the required level of occupants' satisfaction indicates that buildings and real estate perform as intended in terms of function and design. Moreover, the Table 7.2 summarised the findings from literature review of this chapter; along with the identified emerging risks in terms of occupant dissatisfaction are summarised in Table 7.3 below.

Issues Learned from the Literature Review	Argumentations	Research Gaps	Research Questions
What are the occupant dissatisfaction risks that emerge from CCS?	As the literature review discussed in this chapter, the CCS have a direct impacts on the internal environment of buildings and will result in the dissatisfaction of buildings' occupants.	There is a need to determine the drivers of occupant dissatisfaction risks.	How to measure the occupants satisfaction within buildings?
Is the CCS have a direct risks on buildings occupant?	As per the literature re-view discussed in this chapter, the CCS affect both the indoor environment within property and their occupants which will result negatively on safety and satisfaction of occupants.	There is a need to find out the suitable method in order to investigate the occupant dissatisfaction.	How to measure the occupant dissatisfaction risks that emerge from CCS?
How can the POE factors assist to uncover the occupant dissatisfaction risks?	As discussed in this chapter, POE is considered as the process of evaluate the satisfaction of occupants within buildings and real estate.	There is a need to mapping the interaction between POE, CCS and occupants dissatisfaction.	What are the systematic and practical manner of identifying the occupant dissatisfactions merging risks and their occurrence time scale?

Table 7.2 The Issues Learned from the Literature of Occupant Dissatisfaction Risks

Occupant Dissatisfaction		Emerging Risks identified	Reference
	1	Thermal discomfort	Capon & Oakley (2012); Roaf *et al.*, (2009)
	2	Loss of productivity	Khalil & Husin (2009); Owen *et al.*, (2006); Seppanen *et al.*, (2004)
	3	Heat related health risks	Wilby (2007); Ackerman & Stanton (2006); Garvin *et al.*, (1998)
	4	Building usability impaired	Owen *et al.*, (2006); LCCP (2002)
	5	Business continuity impaired	Finch (2004); LCCP (2002)
	6	Occupant litigation	Lord *et al.*, (2012); Owen *et al.*, (2006); Clark (2003)

Table 7.3 The List of Identified Emerging Occupant Dissatisfaction Risks

CHAPTER 8: LIABILITY AND RESPONSIBILITY EMERGING RISKS

8.1 Introduction

Increased demand on energy sources are a key requirement in many daily activities, such as heating and cooling, and all lead to increased emissions of greenhouse gases (GHGs), which are recognised as being the main driver in the emergence of climate change risks. These risks range from mild or disastrous at all levels of living (Weisbac, Undated). Consequently, there is a range of several risks emerging from climate change scenarios on buildings and real estate, all of which position professionals in the building sector—such as owners, managers and designers—to face risks regarding the responsibility of their property. Currently, there is no clear system to determine the responsibilities for climate change risks (Griffiths and Smith, 2011). The question here centres on where these liability and responsibilities for the potential risks emerging from climate change scenarios should be positioned.

In this chapter, there will be the discussion and review of the liability and responsibility of professionals in the building sector concerning emerging climate change risks.

8.2 Liability and Responsibility

8.2.1 Definition

Liability is defined by the Oxford Dictionary as *'the state of being legally responsible for something; Also can be refer to a person or something that cause a lot of problems and damages'* (Oxford, 2013). Moreover, liability, as defined in the Longman dictionary, is *'legal responsibility for something especially for paying money that is owed, or for damage or injury; and from law perspective is the amount that something is likely to be affected by a particular kind of problem'* (Mayor, 2013). Therefore, liability may be translated as the law, as illustrated above; however, the correlation to climate change remains uncertain. According to Lord *et al.,* (2012), the term liability is understood to mean '*in respect of another person, so whenever a liability is under discussion one must also consider the corresponding rights*'. According to Griffiths and Smith (2011), climate change liability can be defined as the concept that the law may provide redress or remedy to those who are or may be adversely affected by climate change, and to control for or provide compensation for the behaviour of those public or private actors who may be directly or indirectly responsible for it.

In addition, responsibility is defined in the Oxford Dictionary as *'the state or fact of having a duty to deal with something or of having control over someone or being accountable or to blame for something'* (Oxford, 2013).

In this research project, liability and responsibility have come to be used to refer to the burdens and responsibilities caused by the risks emerging from climate change scenarios in the building sector against owners, developer, designer and insurers, adopting a legal perspective.

8.3 The Liability and Responsibility of Climate Change on Building Sector

From the building sector perspective, climate change liability and responsibility's associated emerging risks can be divided into two groups, namely the liability of climate change scenarios and the responsibility of professionals, including advisers, designers owners and developers, in terms of protecting stakeholders, their buildings and real estate. The following parts of this research will illustrate these risks emerging from climate change scenarios from a liability and responsibility perspective.

8.4 Emerging Liability Risks from CCS

It is important to recognise that the risks emerging from climate change scenarios are affecting every sector in the building environment over the entire world, with impacts felt in many ways; this has become a significant risk facing the world (LIU, 2010). From a buildings and real estate perspective, climate change leads to diverse emerging risks, including health and wellbeing risks, which may be felt by building occupants (Garvin *et al*., 1998; De Wilde and Coley, 2012). Moreover, such risks result in more actions, including litigation, disruption to business and increased claims, as will discuss in the following sections.

8.4.1 Danger to Health

Climate change scenarios, including changing temperatures and extreme events, such as flooding and storms, are recognised as key drivers for many diseases and health problems due to their impacts on indoor air quality and changes to building environments. According to Environment Protection Agency (1997), the indoor environment of buildings is considered a crucial and critical concern at all levels of the buildings' drivers, and need to be recognised by owners, managers and occupants due to their potential health risks. Importantly, it has been found in some studies that the indoor environment could have higher levels of pollutants than outside.

Additionally, Liberty International Underwriters (2010), states that the health risks associated with climate change patterns are various and stem from changes in temperature, air pollution and extreme climatic events, all of which help to breed and spread disease vectors. Moreover, climate change scenarios are responsible for many health and well-being risks, including those relating to mental health, stress and depression, which stem from the buildings' environment and atmosphere (Hunt and Watkiss, 2011). In addition, Chalmers *et al.*, (2009), add additional health risks as a result of climate change patterns, including injuries and deaths, skin problems, mental health problems and anxiety, as climate change scenarios control the indoor environment, as illustrated in the previous chapter.

In the same vein, the poor indoor environment, including increases in temperature, will lead to a reduction in air quality in buildings and real estate, which can cause diseases, especially asthma, and which also contribute to increased mortality rates due to thermal pressure. Furthermore, rising temperatures threaten health in terms of the heart, increasing the rate of sudden death and the risk of heart disease and heart attacks (Wilby, 2007).

It is clear from the above discussion that the risks emerging from climate change scenarios are responsible for the emergence and spread of most health risks and problems, especially in the building sector. This responsibility is owing to its impacts on buildings' environment and associated risks impacting business and building occupants. As a consequence of these effects, the liability and responsibility of buildings and real estate mangers, owners and designers to take suitable action are increased, such as in line with risks on their property; if not done so, the possibility of litigation might be increased. Moreover, the effected drivers, such as occupants, could more towards suing those responsible for the protection of the environment or those on the list of contributors to increased climatic risk through non-compliance to the reduction of GHGs.

The next part of this chapter will discuss the possibility of environmental litigation in greater detail.

8.4.2 Increasing Environmental Litigation

The environmental litigation is not a new field in law; this was started with air and water pollution in more than a century; however, during modern times, the environmental litigation has expanding with set of challenges in lawsuits (Poustie, 2012). According to Dupar (2012), climate change litigation or environmental litigation is a flexible concept. Environmental litigation is likely to include many of the lawsuits and claims, such as the following:

- Litigation against governments due to enacting laws on climate change in terms of its causes and risks.
- Litigation against institutions and companies to their responsibility in increasing this risk.
- Litigation from individuals who are vulnerable to such climate risks.

Projects related to the environment, such as power projects, infrastructure and transmission facilities that serve them, incur environmental problems. Failure to find proactive solutions to such issues will lead to environmental litigation, which may interfere with the operations of the projects; this subsequently impairs functioning and increases the complexity of this litigation (Brown, 2010).

The dangers posed by climate change patterns have become one of the familiar problems in lawsuits—and are even considered one of the most important litigations. From an environmental litigation perspective, litigation against emitters of greenhouse gases, such as factories, witness power plants coming in first place. For example, in such litigation, Federal States of Micronesia have raised a case against the largest coal-fired power station in the Czech Republic due to their GHG emissions (Dupar, 2012).

Most of the issues under the environmental litigation may pour in greenhouse gas emissions, which is the main cause of climate change with its associated risks. This environmental litigation will go against the companies, and plants or even governments due to their policies and behaviours adopted in order to cope with climate change risks and their causes.

According to Dupar (2012), there has been increased environmental litigation, which may dramatically increase in the near future. Furthermore, in the United States, there has been a sharp rise in such cases, where the number has risen from a single issue, with more than a hundred environmental litigations during a seven-year period, which have fallen between the periods of 2003–2010. Most of these issues were witnessed by environmental groups in their quest to impose and implement projects and policies of the reduction of greenhouse gas (GHG) emissions (Lord *et al*., 2012).

In addition, there was more environmental litigation around the world, which can be seen in the lawsuit from US airlines against the EU; the EU won the case. The European Union imposed upon airlines flying into their airports the purchase of carbon credits because of the increased pollution caused. Moreover, low-carbon fuel action plans were devised by the state of California and litigated by prosecutors representing the US biofuel industry (Dupar, 2012). It is clear that environmental litigation is a complex issue, as it is a right for all without exception against everyone. By way of example, lawsuits from governments go against companies and businesses if avoiding the policies and strategies of the reduction of greenhouse gas emissions. Moreover, on an individual level against both governments and companies in the non-availability of information and precautions in order to avoid or adapt to climate change risks, these types of issue may cause disruption in the projects and business over many sectors and levels. This will result in an imbalance in services provision, which may lead to lifting claims to stop working or operating.

8.4.3 Increasing Decommissioning Liabilities

There has been a marked increase in the emissions of greenhouse gases due to increased manufacturing in the world, as well as human activity, and as a result it is very likely to see a very quick growth in the emissions of GHGs. Furthermore, Griffiths and Smith (2011), indicate that the emissions of greenhouse gases continue to grow despite the presence of international efforts since 1992 to set limits on these emissions. According to Allen (2003), there is considerable potential for the existence of collective lawsuits due to the increased risk of climate change patterns. These suits include high claims for governments and large corporations, such as manufactured energy firms, to take responsibility in terms of increasing emissions of greenhouse gases (GHGs), such as carbon dioxide (CO_2). Moreover, governments and organisations at various levels are exposed to legal litigation due to neglecting and ignoring their environment liability and responsibility towards the climate change, which include risk assessments, rates of GHG emissions, and, in particular, the failure of buildings and real estate to meet the demand of adaptation and mitigation under the threat of climate change patterns (Dowden, 2005).

Consequently, companies and businesses may face mounting claims to stop operating due to the amount of emissions from their factories and buildings, which negatively affect the environment. Increases in political and media interest in the issue of climate change and their causes, such as global warming, could lead to increases of such claims. Moreover, they are likely to face different types of liability claim of climate change, such as responsibilities towards their employees, including their safety (Munich RE, 2010).

In the same vein, projects and related services have faced disruptions and stop problems due to the large number of decommissioning liability cases along with the impact of climate change risks on their operational plans. Correspondingly, the opponents of development projects resort to raising such issues to halt development or new projects (Brown, 2010).

It could be stated that it is very likely to increase decommissioning liability, which includes demands to stop operating buildings and real estate—or even new projects—due to a lack of ability to adapt the potential risks of climate change or their potential impact on increasing GHG emissions, respectively.

8.5 Emerging Liability Climate Change Risks

This section will focus on the responsibility of professionals, such as owners, designers and advisors, the responsibly of whom rests in the buildings in terms of design and operation. This responsibility includes their liability to protect buildings and their occupants from the risks emerging from climate change scenarios. Moreover, they bear more responsibilities, such as adapting adequate warnings of the expected risks from climate change patterns. Equally important is the implementation of policies and strategies to adapt new buildings with such risks—and even existing buildings.

8.5.1 Recourse Action Against Professional Advisors

According to Lord *et al.*, (2012), legal claims, as based on allegations of actual and potential damage from the risks of climate change scenarios, are considered relatively new and, for example, almost non-existent in the UK. The reason behind this is that the responsibilities towards climate change risks (for example: the responsibility of professionals advisers to the buildings from first stage which is design to operation and maintenance) were not clear owing to the lack of scientific evidence on the causes of climate change patterns; however, such issues become very possible due to the severity of the impact of climate change scenario risks, despite the presence of claims to determine the liability towards such climatic risks (Lord *et al.*, 2012).

In addition, with the increase of emerging climate change risks on the building sector in particular, there will be a likely rise in the number of claim cases made against professional advisors, including architects or other associated public bodies. This is due to their failure to incorporate and consider the risks of climate change on buildings and real estate, and their ability to deal with such issues through applying practical and effective solutions in such cases (Munich RE, 2010). For instance, in green building, if professionals fail to take steps and measures to mitigate GHGs emissions, this will lead to the loss of important certificates, which otherwise would prove the level of environmental responsibility of the building, such as LEED certification; hence, they become more likely to face more lawsuit claims (Plushq, 2012). Potential threats of litigation against professionals and buildings' developers may increase because they did not take into account the potential risks of climate change and left the occupiers of buildings to face such climatic risks alone (Land Use Consultants, 2006). Furthermore, the recourse action against professionals can arise from a wide range of professional activities and business: for example, nowadays, many countries require reports for new projects in terms of their environmental impacts and, in the case of these reports, are inaccurate. This will result in the prosecution of the professional (Plushq, 2012). These are a warning to professionals in the building sector, such as advisors, designers, architects, owners and developers, which require that they take immediate actions in terms of their liability and responsibility towards potential emerging climate change risks on their buildings and real estate, as well as their occupants (Dowden, 2005). The increase in the pace and magnitude of the emerging risks on buildings and real estate lead to increases and the emergence of litigation action against designers, architects, developers and owners. This is due to their responsibility to make buildings and real estate more resilient to the potential risks of climate change, or even to give advice and change policies.

8.5.2 Increased Claims in Contract or Tort

It is very important to consider the risks emerging from climate change on assets during the first stages in the agenda of their professional to avoid any potential claims (LIU, 2010). Additionally, claims in contract or tort are recognised as a type of litigation relation to the risks of climate change patterns, where negligence in adopting the regulations and strategies related to the impacts of the projected risk of climate change are one of the key responsibilities that need to be taken into account in the design and operation of the buildings (Munich RE, 2010). According to Dowden (2005), adopting a buildings and real estate perspective, owners, developers, managers and their professionals are responsible for ensuring the possible risks emerging from climate change are taken into account at all stages, including design, planning, construction, operation and beyond. Hence, it is advisable that, in the initial stages of the projects, special care is taken to understand and comply with environmental laws, as well as completing an assessment centred on the potential risks emerging from climate change patterns, which this will help to avoid increasing litigation and claims (Brown, 2010).

According to Koval (2013), as shown in Table 8.1, professionals have a responsibility in relation to the risks of CCS.

Professionals	Potential Tort
Designers	– Negligent in designs. – Failure to warn. – Negligent supervision and inspections.
Owners	– Contractual entrants. – Licensees. – Invitees and trespassers due to unsafe properties.
Contractors	– Failing to construct according to design specifications. – Failure in implementation. – Failure to use methods and materials of construction appropriately and reasonably.
Governments	– Negligent inspections.

Table 8.1 The Responsibilities of Professionals; Source: Koval (2013)

8.5.3 Responsibility of Mal-adapted Buildings and Real Estate

Adapting buildings and real estate with the potential risks emerging from climate change scenarios has become a pressing issue at the present time due to what it might induce in terms of legal responsibility for professionals in the buildings sector, where responsibility centres on planning, design, development and operating process under the umbrella of adapting buildings and real estate in regard to climate change pattern risks (Koval, 2013). Failure to take actions and decisions—or even to offer advice—concerning the potential risks emerging from climate change scenarios in the early stages of building, or even during the lifecycle of buildings and real estate, will lead to rises in the legal issues against professionals and their team (Dowden, 2005).

Moreover, it is expected that there will be much litigation against professionals, including designers, advisors, owners and insurers. Such lawsuits will concern the failure to adapt buildings with risks emerging from climate change in terms of design and operations, as well as planning civil engineering projects. These responsibilities are not only shouldered by the buildings' designers or operators, but also by professional advisors, investors, lenders and insurers (Lord *et al*., 2012). In addition, planners, councillors, developers and politicians are responsible for adopting effective procedures in the short-term in an effort to protect people from the consequences of climate change risks (Roaf *et al*., 2009). In actual fact, it is difficult to avoid potential litigation from occupants and employees, especially in poorly performing buildings and real estate. This litigation becomes real and faces responsible professionals in the building sector (Clark, 2003). According to Faure and Peeters (2012), the responsibility is also shouldered by governments and civil authorities, forcing professionals in the building sector to take action and to adapt buildings and real estate to climate change risks, which in turn leads to the reduction of GHG emissions. It is widely expected that, in the near future, there will be the use of courts to compel governments and civil authorities to take action towards adapting buildings in line with the risks of climate change. Consequently, this will be reflected into professionals' responsibility in such circumstances (Dupar, 2012).

8.6 Summary of this Chapter

It is obviously clear that the liability and responsibility in the building sector is a joint process between climate change and associated risks with professionals, such as advisors, architects, designers, developers, owners and managers, where climate change is primarily responsible for the health risks because of its negative impacts on the internal atmosphere of the buildings, which could lead to increases in the probability of litigation due to the consequences resulting from these risks.

Issues Learned from the Literature Review	Argumentations	Research Gaps	Research Questions
What are the L.R risks that are emerging from CCS?	As discussed in this chapter, the professionals and practitioners in the building sector are in the charge to protect buildings and real estate as well as their occupants.	There is a need to clarify the L.R risks that occur as a consequences of CCS	How to identify the emerging L.R risks and their occurrence time scale?
Is there a clear guideline in the building sector for L.R of different level pf professionals and practitioners as well as occupants?	As per the literature re-view discussed in this chapter, there is no systematic approach for the L.R towards the risks emerge from CCS.	There is a need to uncover the L.R determinants and their emerging risks.	What is the practical way to translate the professionals and practitioners L.R in the building sector in emergence of L.R risks?

Table 8.2 The Issues Learned from the Literature of Liability & Responsibility Risks

Likewise, for professionals, the responsibility is identifiable from two sides: the first is to consider the warnings and clear instructions of the potential risks arising from climate change; the second part of their responsibility is to follow and apply the methods and policies that help buildings to adapt to climate change risks.

Table 8.2 summarised the discussion and observation from literature review in this chapter as well as the fully identified emerging liability and responsibility risks arising from climate change patterns are presented in Table 8.3 below.

		Emerging Risks identified	Reference
Liability & Responsibility	**1**	Increase of recourse action against professional advisors	Plushq (2012); Lord *et al.*, (2012); Munich RE (2010); Owen *et al.*, (2006); Dowden (2005).
	2	Buildings dangerous to health as a result of high temperature	Hunt & Watkiss (2011); LIU(2010); Chalmers *et al.*, (2009)
	3	Increase of claims in contract or tort because buildings designed, or operated in a way that has insufficient regard to the reasonably anticipated impacts of climate change	Brown (2010); Munich RE (2010); LIU (2010)
	4	Increasing environmental litigation	Dupar (2012); Poustie (2012); Lord *et al.*, (2012); Dowden (2005)
	5	Increasing decommissioning liabilities	Brown (2010); Munich RE (2010); Dowden (2005)
	6	Professionals (advisers, designers, owners, tenant, insurers) will bear the responsibility of mal-adapted new buildings	Koval (2013); Dupar (2012); Faure & Peeters (2012); Roaf *et al.*, (2009); Dowden (2005); Clark (2003)

Table 8.3 The List of Identified Emerging Liability & Responsibility Risks

CHAPTER 9: REPUTATIONAL EMERGING RISKS

9.1 Introduction

The building sector has directed focus by investment companies and individual investors around the world due to the steady growth rates in real estate prices; however, the risks stemming from climate change scenarios—especially on buildings and real estate—may adversely affect the operating performance of such investments, such as by reducing the life span of buildings and causing interruption for businesses (Velpuri and Pidugu, 2012), which may, in turn, lead to additional risks, such as in terms of reputation. Reputation risks, which are associated with the risks of climate change patterns, are recognised as the essential risks for many sectors, and are increasingly important due to the adverse effects on business, along with the attention of communities and individuals on companies and establishments who are environmentally responsible (Kwan, 2009). Affected sectors from risks of climate change scenarios will suffer from reputational risk, as much as the mismanagement of the risks emerging from climate change patterns (Knobloch and Leurig, 2010). Nevertheless, the reputational risks from climate change scenarios are real emerging risks, which threaten most sectors by influencing and harming their buildings and real estate.

This section of the research illustrates the concepts of reputation, and the relationship between emerging reputational risks and climate change scenarios. This will lead to and assist in identifying the emerging reputational risks from climate change scenarios.

9.2 Reputation Concept

Reputation risks are known to be the critical risks, which organisations, companies and risk managers must identify and consider. Protection from this kind of risk requires determining the concept (Ross, 2005).
Reputation is defined in the Oxford Dictionary as '*the beliefs or opinions that are generally held about someone or something or as a widespread belief that someone* or *something has a particular characteristic'* (Oxford, 2013). Moreover, in Longman (2014), the concept is defined as *'the opinion that people have about someone or something because of what has happened in the past'*. From a buildings and real estate perspective, Knobloch and Leurig (2010) described Reputational Risk as the results of other risks emerging from climate change scenarios, which are known to have occurred and impacted organisations and

companies, and which may lead to suffering reputational risks due to mismanagement towards the potential risks from climate change. Moreover, according to Ross (2005), reputation risks can be defined as the failure and decline in the level of experience and services, and does not fulfil the level of expectations. The different effects of risks from climate change scenarios on buildings and real estate cause different indirect emerging risks, referred to as reputational risks. This will lead to a bad reputation as a consequence of such emerging climatic risks—whether on buildings and real estate themselves, or otherwise on their facilities and the services they provided (Roaf *et al.,* 2009).

Reputation is recognised as the cornerstone to success and the continuation of any projects, and the sensitive centre for all sectors. This is why they always strive to achieve their goals: whether to increase profits, maintain customers or even expand at a local, regional or global level. The question here is concerned with the relationship between the climate change scenarios and the emergence of reputational risks in relation to buildings and real estate, procurement and operation. This is what will be illustrated in the next part of this chapter.

9.3 The Relationship between Reputational and CCS

The correlation between climate change scenarios and reputational risks can be seen as mutuality relation, whilst the reputational risks occur as a result of the various risks of climate change patterns on buildings and real estate. Moreover, reputational risk is recognised as one of the most significant risks arising from climate change scenarios, where the lack of attention to the climatic risks and the initiative to reduce the risks of climate change will push organisations and companies to act as contributors to climate change, thus negatively affecting their reputation (Rosnes *et al.,* 2011). According to Bergen *et al.,* (2008), reputational risks are seen as non-tangible risks, and the relationship with related climate change risks is still in its infancy. Nonetheless, there is a strong relationship between the other risks emerging from climate change scenarios, such as physical, operational and economic risks with the emergence of reputation risks. This reflects negatively on the evaluation of buildings and real estate, as well as their owners. The impacts of reputational risks are various and independent of other risks of climate change; however, these reputational effects have appeared as a result of the consequences of other of climate change risks. It can be stated that the reputational risk arising as a result of failure in business or providing services may occur due to the effects of various climate change pattern risks on buildings and real estate. This failure is reflected on the inability to provide services or products, as required, thus resulting in more reputation risks (Ross, 2005). According to Roaf *et al.,* (2009), by way of illustration about this relationship between the emergence of reputation risks with climate change and other risks of climate change patterns, physical risks that would cause damages and destruction to buildings will result in the creation of significant problems at all levels. These problems will lead to the emergence of bad reputation—whether for governments, authorities, owners of building stocks and companies such as insurance or even for the area that have damaged buildings.

It can be deduced that the risks of climate changes scenarios, such as physical and operational risks on buildings and real estate, will result in the emergence of reputational risks that control the reputation of governments, organisations, owners and professionals in the building sector—or even the affected property and areas. These type of emerging risks may vary based on the causes and effects.

The next section will illustrate and discuss the types of emerging reputational risks from climate change scenarios.

9.4 The Reputational Risks from CCS

As clarified above in regard to the association between reputational risks and other risks of climate change scenario, based on this, emerging reputational risks will be divided into four groups, as presented below.

9.4.1 Reputational Risks from an Economic Context

Build on the earlier discussion in this chapter of the research project, climate change scenarios will induce economic risks to many sectors around the world. According to Symon (2013), the various risks of climate change patterns, which affect all sectors, will lead to creating different economic risks. According to Guruswami (SDM Institute for Management Development), as cited in Ross (2005), reputational risks are considered to be the starting point for all other risks, and economic risks in particular. From a reputational perspective, Ross (2005), carried out a study on reputational risks, declaring that the association between reputational risk and other risks leads to multiple economic risks. This study found that the economic losses from reputational risk could be bigger and stronger than direct risks. Such reputational risks might range economically between weaknesses in competitive strength in the market, a loss of economic benefits and the decreased value of shareholders, with such risks potentially fatal to governments, organisations, and buildings and real estates' owners . In relation to the building sector specifically, the effects of risks from climate change patterns on buildings and real estate will result in the distribution of the business and daily works. Such risks will negatively affect the reputation of the buildings and real estate, and will increase reputational risks to owners and developers, such as economic effects.

Built on this, the building sector might be become more exposed to market differentiation due to the emerging risks from a reputational standpoint.

The risks of climate change scenarios play a key role in market differentiation in terms of enhancing various features of the market and putting pressure on others, and this could be the main reason for the emergence of market differentiation. For instance, in the availability of land, residential buildings, and real estate owners and developers in this field, focus is directed towards adding features and services, which increases interest in their products, thus leading to increases in purchasing power—especially in areas under the threat of climate change scenarios, such as floods (Hertin *et al.*, 2003). Moreover, this will result in increased confidence and rises in reputation within the market, which might positively reflect on contributing to bridging the gaps and effects from the risks of climate change patterns.

In the same vein, it is difficult to determine risk indicators from market differentiation; this depends on two factors, the first of which is the severity and strength of the risks of climate change scenarios, whilst the second is the type of procedure followed by other entities, such as owners, developers, suppliers or customers (ibid).

A good reputation can be established and maintained, although it is not an easy process, especially in the building sector. It is not through only the perfect technical operation of the buildings and real estate, but it comes as a result of a series of overlapping operations, including coping with the risks emerging from climate change (Finch, 2004). These processes may also include the availability of services and facilities and work as required, regular maintenance, and providing a good atmosphere in the property, all of which will help companies and developers in the building sector to distinguish themselves from competitors in the market and accordingly to achieve stakeholder satisfaction, thus leading to conserving investors and consideration directed towards investment market (ibid). According to Ross (2005), a good reputation plays a vital role in bringing investors to the building sector. However, owners and developers focus more so on the economic aspects as a real danger that threatens them; this consideration includes raising financial performance, the achievement of profits, and safeguarding the rights of shareholders. Nevertheless, the reality is that reputational risks—resulting from climate change scenarios—are a foundation, and must be considered seriously as the main cause for such economic risks (Ross, 2005).

Likewise, the brand will be adversely affected by the impact of climate change risks, which will result in affecting the commercial value of the brand, which may have a market and historical value in the building sector, thus distinguishing them from other competitors (Bergen *et al.*, 2008). Moreover, according to Knobloch and Leurig (2010), this negative effect on building and real estate brand is due to the link between the brand and the risks emerging from climate change scenarios. In addition, these risks on the brand may increase due to the severity of climatic risks along with mismanagement of such involved risks.

According to CEO (2014), it is widely accepted that the responsibilities towards the potential risks of climate change scenarios continue to increase across all organisations and companies, especially in relation to the building sector. Furthermore, based on the study carried out by Tubb *et al.*, (2003), the possible risks from climate change scenarios on the building sector will affect the performance of buildings and real estate, and accordingly will result in business interruption, along with the losses of customers. For example, the risks on water companies, such as water pollution and a lack of water, will lead to owners and building stock managers, to face investors and consumers. This increases the exposure to more business risks, which may damage reputation (CEO, 2014). Similarly, in the buildings sector, different emerging climate change risks have been inflicted on property and disrupted buildings and real estate, which has also led to the increased non-validity of such property. This could be a driver of the emergence of a bad reputation for buildings or the services provided, thus impacting clients and investors, as well as employees and occupants.

In addition, the CEO (2014) indicates that the risks emerging from climate change patterns could incur more reputational risks, as presented below:

- Low brand value.
- Loss of consumer and investor along with their confidence.
- Negative impact on social responsibility.
- Legal risks.

It is clear that there are many reputational risks resulting from exposure to climate change scenarios. The emerging reputational risks affecting buildings' owners, developers and managers in terms of the economy will be a consequence of bad reputation, leading to a loss of customers and a lack of investment fortune. Reputational risk may appear from the standpoint of social considerations, such as by contributing to the causes of climate change, such as through increased emissions of GHGs, thus resulting in earning a bad reputation amongst different communities. These emerging reputational risks can be identified from a social perspective, as detailed in the next section.

9.4.2 Reputational Risks from a Social Context

In general, based on the work carried out by the International Association for Impact Assessment (IAIA, 2003), it has been declared that, from a social perspective, all risks and variables affect humans within society, and changing patterns of their daily life, whether environmental, economic and health, are under the focus, attention and criticism of society. Therefore, the building sector has assigned responsibilities to these communities, especially buildings and real estate, which are known to have a correlation with society.

In addition, according to Dowden (2005), buildings' owners, developers and investors need to consider the importance of social responsibilities in terms of reputation, where it adversely affects reputation. The reputation of buildings and real estate forms the basis for legal and environmental obligations, which need to be faced from social perspectives. This means that the approach of owners, developers and construction companies in the community maintain a good reputation, which will increase the value and accordingly will correlate and overlap with all levels of society. In addition, this also will lead to the existence of positive standing and support from societies in the event of exposure to legal responsibility. In terms of reputation across construction companies, attention to environmental responsibility is included as one of their responsibilities, which contributes to raising the reputational index of these companies and developers in the communities (Echegaray *et al.,* 2008).

Moreover, this interdependence occurs by providing services, as required, through the provision of suitable buildings and facilities for business and the environment, with no negative impact on the environment. For instance, in the United States, there is a transition in the risk assessment of the building sector, from binding rules to value based. This is through the inclusion of social and environmental issues in the evaluation of the potential risks from climate change scenarios, such as buildings' failure to meet the requirements and design roles commensurate with the climate change patterns and emissions of CO_2 (Dowden, 2005).

It is clear that the responsibility and obligations of owners, developers and constructors to communities play an important role in building a good reputation through the preservation of the environment by providing environmentally friendly property and considering the reduction of GHG emission approaches. The negative impact on social responsibility leads to the loss of reputation and also affects the adoption of the sustainability of such developers and construction companies.

According to Clark (2003), claims that carbon emissions from buildings, whether residential or commercial, are continuous and increasing sharply due to excessive and unsustainable

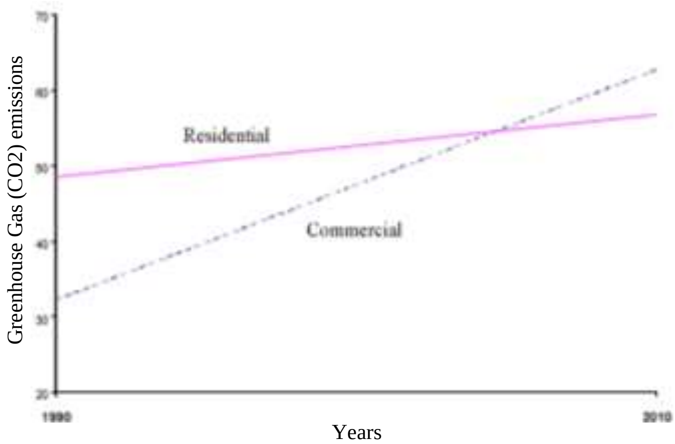

Figure 9-1 Projected CO2 Emissions form Buildings and Real Estate; Source: Clark (2003).

operations in the building sector, such as misuse, a lack of maintenance, consumption of energy and ways of waste disposal. Figure 9-1 above highlights the increase in the emissions of greenhouse gases from buildings and real estate, both residential and commercial property.

The emissions exacerbating the risk of CCS on buildings and real estate cause a burden on buildings' management, including owners and developers, in terms of reputation in their role to act responsibly to reduce the emissions of greenhouse gas. Such emissions from property will be costly to owners and developers, and they might become keen to follow the needs and aspirations of occupants and investors. Neglecting such requirements and aspirations will ultimately result in a bad reputation for their buildings and real estate stocks (Velpuri and Pidugu, 2012).

Contributing to climate change scenarios by increasing CO_2 emissions from projects and buildings will create campaigns and steps from societies against construction companies and could ultimately harm their reputation, such as that which occurred in the case of ExxonMobil, which had been exposed to many campaigns from consumers and investors, thus causing discredit to their reputation around the world. This contribution will adversely affect the reputation of the corporation and would hinder their various capacities, including competition ability in the market, and would also maintain the position with consumers (Atkinson, 2007). Increasingly, consumers become more aware of environmental issues, and look seriously for developers and construction companies that degrade the climate change risks under their attention. This has begun in Europe, as can be seen in the case of consumers demanding labelling the description of carbon footprint. This will affect the reputation and market competition, leading to increases in the risk of reputation—especially for emerging developers and construction companies that want to prove themselves in the building market (Kwan, 2009). For example, in New Zealand, Colmar Brunton Market Mood Monitor in March 2007, as cited in Atkinson (2007), it is highlighted that around 25% of New Zealanders take into account the company's contributions to GHG emissions when doing business with them. Likewise, approximately 12% of the population have stopped buying products or services from companies and developers with a bad reputation in dealing with the risks of climate change. Furthermore, reputational risks, from being seen as a contributor to the risks of climate change patterns, are considered substantial threats and are increasing continuously, with this expected in the near future (Rosnes *et al.*, 2011).

It can be seen that the reputation of buildings and real estate, and their owners, developers or constructors are affected by communities in two ways, namely directly, through a lack of commitment to social responsibility and environmental responsibilities, especially those related to climate change risks, and indirectly through the spreading of bad reputation amongst societies in terms of the contribution to climate change scenarios, such as by increasing CO_2 emissions. These contributions to the causes of climate change scenarios, which increase emerging reputational risks, could lead to other reputation risks, which stem from buildings' and real estates' occupants. This will be discussed in the next part of this chapter below.

9.4.3 Reputational Risks in an Occupant Context

Risks of climate change scenarios will be increasingly bad on human health in general and on inappropriate environments in particular (Ackerman and Stanton, 2006). It is widely accepted that the work environment is very important, and it is a requirement for both employers and staff, with employers looking to increase productivity and employees looking to work in a comfortable and safe environment.

According to Thomas (1998), as cited in Capon and Oakley (2012), the internal environment within buildings and real estate play a vital role on the occupants of the place, which will adversely affect their health and productivity at work in the case of an unsuitable environment. The conclusion has been drawn in the report of London Climate Change Partnership (LCCP, 2002) that the deterioration of a building's environment will lead to limiting the services provided, as well as the continuity of the business. This will also result in the decreased productivity of employees, along with the inability to bring in staff due to a lack of appropriate work environment.

Moreover, according to Clark (2003), owners and developers focusing on providing sustainable buildings and real estate that are able to provide a suitable environment and convenient for employees and occupants should consider improving lighting and ventilation, and the good control of the internal temperature of the building. These factors will lead to increased comfort and productivity, and will also enhance quality. This will result in an increased reputation of property, or even their company and management. In addition, Atkinson (2007), points out that the most important emerging reputational risk is incurred on buildings and real estate, which affects organisations and companies, such as in terms of the inability to recruit employee and retain staff. This leads to an impact on productivity and competitiveness.

In the same vein, the lack of a suitable environment in work places increases the rates of absenteeism, which, in turn, affects the level of production (Clark, 2003). This poor environment in the workplace occurs as a consequence of the risks of climate change patterns on buildings and real estate.

Equally important, the potential risks of climate change scenarios on buildings and real estate affect occupants, which will increase pressure on staff and accordingly increase their stress in an inappropriate environment, thus leading to increased sick days and lower motivation. The correlation between poor work environment and its impacts on occupants' health will encourage staff to be absent from work (Graves and Phillipson, 2000). Furthermore, disturbances in the business environment, especially changing temperatures, lead to interruptions or completely stopping work due to an increased rate of sick leave or staff absence, thus resulting in a bad reputation (Tubb *et al.*, 2003).

It could be stated that the emerging reputational risks come from occupants or staff, and that these are various. These emerging risks may be sharp on buildings' owners and induce greater effects as a result of business interruption and the absence of staff, as well as lower staff retention. Additionally, this may lead to more risks, such as litigation against owners, developers, and managers of buildings and real estate from occupants or society. This will be illustrated in the next part of this chapter.

9.4.4 Reputational Risks in a Legal and Liability Context

It is very difficult to predict the probability of the occurrence of litigation risks on owners, developers and managers of property that perform poorly. This greater legal risk can stem from buildings' occupants as a result of their exposure to various risks within the building environment or from the community due to the environmental effects from buildings and real estate (Clark, 2003). Moreover, Dowden (2005), declares that the increased liability of risks associated with the risks of climate change scenarios lead to increasing the likelihood of litigation as a result of negligence across these liabilities. These liabilities include taking the necessary measures against the possible risks emerging from climate change patterns and adapting buildings and real estate with such climatic risks. These will lead to the protection of occupants and employees, with higher legal risks avoided. Deterministic liabilities at all levels—whether in organisations or within buildings—and prioritisation help to avoid many of the risks related to climate change; however, failure to fulfil these liabilities, as well as increased legal risks, will result in the increased probability of the emergence of bad reputation.

9.5 Summary of this Chapter

It is clear that the emerging reputational risks arising from the risks of climate change scenarios on the buildings sector are various and different; however, they meet in their negative impacts on owners, developers and managers. The appearance of the reputational risks depends on the effects of other risks of climate change scenarios, such as physical and operational risks, which disrupt buildings and real estate, and countenance of business, which will result in the emergence of bad reputation. Such reputational risks are continuously increased based on the pace and magnitude of related risks from climate change patterns, and are also linked to the extent of social responsibility from organisations and companies to the communities through the reduction of the contribution to causes of the climate change patterns, such as GHG emissions, from buildings and real estate. This contributes to the cause of climate change, leading to the emergence of a bad reputation amongst communities, leading to economic problems for building investors, owners and developers. Moreover, Table 9.1 presented the summary of the literature review from knowledge and issues perspective as well as the full identification of the reputational risks emerging from climate change scenarios are summarised in Table 9.2 below.

Issues Learned from the Literature Review	Argumentations	Research Gaps	Research Questions
What are the reputational risks that emerge from CCS?	As the literature review discussed in this chapter, the reputational risks are that related to other cluster of merging risks.	There is a need to determine the main driver of the emergence of reputational risks within the building sector.	How to investigate the emerging reputational risks on buildings and real estate?
How can the other groups of emerging risks result in occurrence of reputational risks?	As per the literature re-view discussed in this chapter, there is an interaction between the emergence of reputational risks and other emerging risks such as financial risks.	There is a need to establish the practical manner in investigating the emerging reputational risks.	What is the conceptual method to uncover the reputational emerging risks?
Are there other dimensions of the occurrence of reputational risks?	As discussed in this chapter, the occurrence of reputational risks may result in rise in the severity of other merging risks.	There is a need to find out the correlation between the emergence of reputational risks and other emerging risks?	What is the conceptual method to uncover the reputational emerging risks and their occurrence time scale?

Table 9.1 The Issues Learned from the Literature of Reputational Risks

		Emerging Risks identified	Reference
Reputational Risks	1	Loss of economic benefits	Ross (2005); Tubb *et al.*, (2003)
	2	Negative impact on corporate social responsibility	CEO (2014); Echegaray *et al.*, (2008); Dowden (2005);
	3	Market differentiation	Atkinson (2007); Hertin *et al.*, (2003)
	4	Loss of organisations' sustainability credential	Knobloch & Leurig (2010); Bergen *et al.*, (2008)
	5	Loss of investors	CEO (2014); Finch (2004);
	6	Lower staff retention and productivity due to building usability	Clark (2003); Atkinson (2007); LCCP (2002)
	7	Higher economic risks	Ross (2005);
	8	Higher legal risks	CEO (2014); Dowden (2005)
	9	Higher liabilities risks	Dowden (2005); Clark (2003)
	10	Loss of potential customers due to business interruption	CEO (2014); Tubb *et al.*, (2003)
	11	Negative impact on organisation's brand and reputation	CEO (2014); Knobloch & Leurig (2010); Bergen *et al.*, (2008)
	12	Increased sick days	Clark (2003); Tubb *et al.*, (2003)
	13	Increased carbon emissions	Velpuri and Pidugu (2012); Clark (2003)
	14	Increased level of staff stress	Graves & Phillipson (2000)
	15	Negative impact on organisations reputation from being seen as a contributor to climate change	Rosnes *et al.*, (2011); Kwan (2009); Atkinson (2007)

Table 9.2 The List of Identified Emerging Reputational Risks

CHAPTER 10: REGULATORY EMERGING RISKS

10.1 Introduction

The potential and emerging risks arising within the buildings sector from climate change scenarios are affecting buildings and real estate in varying degrees; hence, legislators and decision-makers in the building sector seek to find solutions in order to adapt the buildings and real estate to climatic risks in order to avoid further damages and preserve the existing premises. Hertin *et al.*, (2003), claim that it is widely accepted that climate change is the only aspect responsible for changes to the regulations and strategies concerning the impacts of climate change on buildings and real estate.

According to Koval (2013), recently, legal liability due to the effects of climate change has been recognised as a major issue, and it is highly possible that this will arise. This explains the reason behind the emergence of the amendments to building regulations and standards, taking into account the potential risks on buildings and real estate from climate change patterns. Importantly, however, these changes are still in their infancy, and there continues to be the need for the existence of climate change regulations in the building sector based on the ideal assessment and understand of such risks, which are related to climate change scenarios (Kwan, 2009). However, building regulations are recognised as one of the four key areas associated with the risks emerging from climate change patterns threatening various sectors (ibid). Moreover, this increases the need for regulations, based on the clarification of the seriousness of climate change to establish fairer collective solutions to the risks arising from climate change scenarios on the building sector (Lorenzoni *et al.*, 2007). For instance, in the UK, building regulations play a pivotal role in protecting the building sector from the potential risks of climate change scenarios by managing such risks through adopting related legislation (CCRA, 2012).

This section of the research project will illustrate the concepts of the regulation and the relationship between climate change scenarios and building regulations. In turn, this will lead to and assist in identifying the emerging regulation risks stemming from climate change scenarios on the building sector.

10.2 Regulatory Concept

Based on Longman dictionary (2014), regulatory can be defined as *'official rule[s] or order[s] and control over something, especially by rules'*. Moreover, in Oxford Dictionary (2014), regulation defined as *'a rule or directive made and maintained by an authority'*.

From a building perspective, regulatory can be described in two ways, as indicated by Gann *et al.,* (1998). In theory, regulations seek to consider single particular goals, and therefore are consistent and organised. In practice, regulations are recognised as multiple interests presenting a variety of considerations subject to change with the passage of time, according to several considerations. Moreover, building regulations, as defined by Bertocchi *et al.,* (2011), are the '*instrument that regulates all direct building interventions and non-substantive urban projects, which can be immediately carried out'*.

Additionally, building regulations are centred on ensuring the health and safety of the occupants within buildings through the provision of design and functional requirements, as well as outside the buildings through the provision of facilities and different needs of all types of occupant (Haringey Council, 2014). Furthermore, the Welsh Government (2014), describes building regulations as including a set of design and structural criteria, leading to ensuring that buildings and real estate meet standards in terms of safety, and the well-being and comfort of occupants, as well as sustainability through energy-saving and ways of using buildings. Moreover, based on Huovila *et al*., (2007), it has been stated that building regulations in most countries around the world play an essential role in the building sector, as it is reference for all activities within the building sector. Meanwhile, building regulations are focused on several aspects, including technical standards, safety and architectural considerations, and environmental requirements—including the indoor environment.

Climate change is the main danger threatening regulations standards, which requires urgent intervention to implement changes. This is what encourages legislators to revise process in line with building regulations in order to cope with the threats of climate change patterns. It can be recognised that there is a sharp rise in the implementation and adoption of the regulations at international, regional and local levels around the entire world (Bergen *et al*., 2008).

In this research project, building regulations, from a climate change perspective, have come to be used to refer to the building regulations related to the various risks of climate change on buildings and real estate, such as floods, windstorms and changing temperatures, all of which negatively impact buildings and real estate, as well as adversely affect buildings through contributing to GHG emissions.

10.3 Association Between Building Regulations and CCS

Usually, the building sector is guided and managed by regulations and standards from very early stages of the building projects, running between design, build, operate and maintain. This might be extended to cover the various energy standards, including energy usage, operation and suitability (Huovila *et al.,* 2007). Moreover, regulations and standards are used in the buildings sector in an effort to identify and accordingly measure the performance of buildings and real estate in different surrounding climatic conditions—especially for new buildings and real estate in the near future in particular (Garvin *et al*., 1998).

According to Bertocchi *et al.,* (2011), one of the main aims of legislation in the building sector is to ensure the quality of urbanisation, assisting buildings and real estate in providing a suitable environment and finding solutions to improve the quality of the environment. This is positively reflected on the performance of buildings and real estate in terms of their adaptation to different conditions of climate change. In addition, building regulations help the building sector to ensure that buildings and real estate are sustainable for the present time, as well as for the future, through the development of comprehensive regulations for new buildings or by various other amendments to the existing buildings (Pan and Garston, 2012). However, there is a need to increase the attention directed towards building regulations (ibid), in terms of the clear mutual relationship between climate change scenarios and regulations. For example, in the UK, building regulations take into account the effects of climate change and the potential and emerging risks on buildings and real estate through various studies and research centred on the possible risks stemming from climate change, with attention also directed towards identifying policies and strategies to cope with such risks. Consequently, these help to track and tackle the impact of emerging climatic risks from a buildings regulation perspective in order to update and amend regulations to comply with the climatic changes. This will result in ensuring that new buildings are in line with such threats of climate change, without there being any effect on buildings and real estate or on their occupants (Garvin *et al.,* 1998). However, building regulations might incur impacts related to climate change on different sectors, which might include new regulations and obligations on the various affected sectors. These changes to regulation due to climate change are highly expected to include greenhouse gases regulations, which may exacerbate the effects to comprise financial loss, for example (Knobloch and Leurig, 2010).

Likewise, the case applies to a large degree in the building sector, where it would be possible to expand to include several aspects related to buildings and real estate, such as energy consumption, materials used, quality, and the operation processes. In addition, there is no clear agreement on the relationship between regulations in the building sector and climate change; several construction professionals, such as designers, have claimed that it is an extra burden, which must follow and apply. In contrast, regulators contend that changes in buildings regulations do not require practice changes, but should achieve the goal of the regulations; others believe that changes in buildings regulations create extensive opportunities for innovation and development in the building sector (Gann *et al.,* 1998).

In relation to climatic changes, Graves and Phillipson (2000) declare that building regulations must be updated periodically based on the potential emerging risks arising from climate change on buildings and real estate, and should be strict and binding. Built on this, regulation risks arising from climate change will occur and lead to various impacts on the building sector. According to Knobloch and Leurig (2010), the emerging regulation risks are considered to be the most imminent risks based on a survey conducted in relation to the risks of CCP.

Figure 10-1 below describes the relationship between climate change and regulations, where there is a gap between buildings' regulations and the risks of climate change (blue area); this is considered the risk area. In the case of keeping the regulations as they are, along with increasing climate change threat, in 2080, the risk zone will become greater (Garvin *et al.,* 1998), thus leading to the emergence of regulation risks that threaten the building sector.

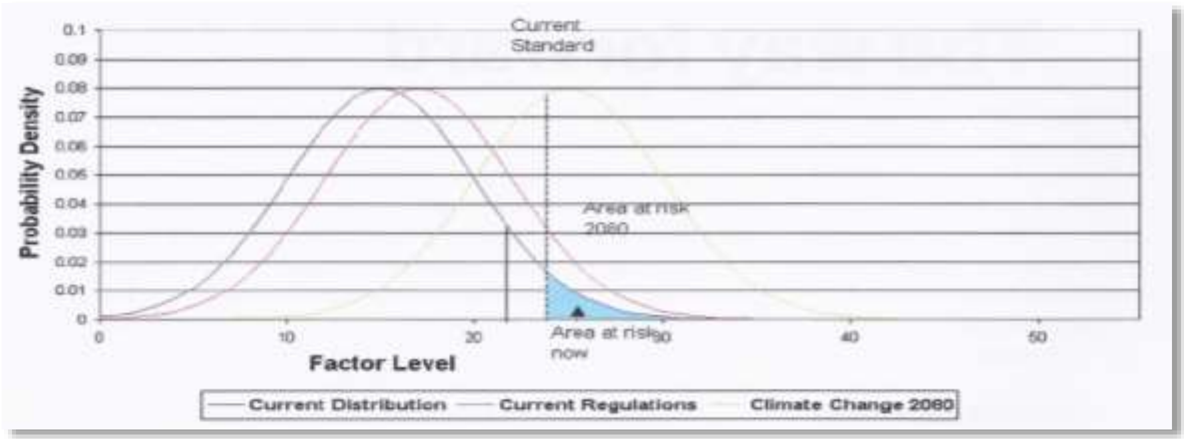

Figure 10-1 Probability of CCR Occurrence in Relation to Regulatory; Source: Graves & Phillipson (2000)

By way of illustration, in the USA, regulation risks related to climate change are referred to as regulatory confusion, where it is very likely that many sectors facing new regulations to deal with climate change risks may be conflicting due to a lack of clear lines of guidance from the government (Walsh, 2006). Similarly, Darier and Schule (1999), as cited in Lorenzoni *et al.*, (2007), declare that, in the UK, many people want the government to impose and renew regulations to conform with responses to climate change scenarios.

From a building sector perspective, it can be recognised that the relationship between climate change threats and potential regulation risks is crucial; there is a need to change or update existing regulations in order to cope with the potential risks of climate change scenarios on buildings and real estate, which could lead to the emergence of more stringent regulations. This may be considered in place of a threat to the buildings sector due to emerging regulation risks. Based on the work by Liberty International Underwriters (LIU, 2010), it is highly expected that managers and directors may face potential action in relation to building regulation, ensuring compliance with the expected effects of climate change patterns.

According to Graves and Phillipson (2000), the various risks of climate change scenarios on buildings and real estate can be absorbed through changes in building regulations. On the contrary, extreme events of climate change patterns—which have become more likely to occur—may have effects and crucial risks in regard to buildings and real estate, such as water shortages, flood stress, windstorm damages and landslides, thus leading to greater impacts. This may lead to the presence of strict regulations against all such serious effects expected to impact the building sector.

It is clear that there is conflict in terms of clarifying the relationship between climate change scenarios and the need to change the building regulations to comply with climatic threats impacts. However, there is a certain point of agreement, which is the risks of climate change leading to changes in building regulations, and potentially resulting in emerging regulation risks, such as regulation in relation to floods, windstorms and water shortages, as well as GHG emissions in the building sector.

The following section of this chapter will discuss the emerging regulation risks arising from the impact of climate change scenarios on the building sector.

10.4 Emerging Regulation Risks

There is an identified association between climate change scenarios and the various impacts on the building sector and building regulations, as discussed above. This correlation leads to various necessary changes in building regulations, which may be binding and strict in all cases. These changes in building regulations are recognised as one of the climatic risks threatening buildings and real estate.

This part will discuss the emerging regulation risks arising from the effects of climate change patterns on the building sector.

10.4.1 Stringent Regulation in Relation to Water Stress

The availability of water is affected by several factors, the most important of which is climate change, which adversely affects water resources (Bertocchi *et al.,* 2011). Moreover, climate change scenarios affect the availability of water in the building sector, and result in limiting businesses, especially those depending on water availability, with people’s use of water also affected by climate change patterns. Therefore, it is possible to experience consequences, meaning regulations should reduce wasteful water and ensure the preservation of its sources (UKCIP, 2003).

In addition, the building sector is facing strict regulations concerning the usage of water in buildings, ensuring the minimum of an efficient use of water in buildings and real estate. Such regulations help in sustainable buildings for the time being and in the future, and are adaptable to climate change factors (CCRA, 2012). Furthermore, Hertin *et al*., (2003), point out that there will be potential indirect risks from climate change scenarios on the building sector through various regulations, including new regulations in relation to water saving and usage. By way of illustration, Bertocchi *et al*., (2011), indicate that the municipality of Bologna in Italy imposes regulations and guidelines to protect water in the building sector. This regulation is a variety, based on several considerations, which aims to reduce water consumption in buildings and real estate.

10.4.2 Stringent Regulation in Relation to Flood Stress

According to Hertin *et al*., (2003), the indirect effects on the building sector might be greater and stronger than the direct effects of different climate change scenarios. The indirect risks will include two main factors, namely building regulations, especially those relating to flooding and the impacts on buildings and real estate; and customer demand, which is influenced by the extent of rigor and strength of such regulations and the level of buildings adopting such regulations. The reluctance of people and investors to purchase and invest in buildings and real estate in areas threatened by floods results in non-viability for development projects in such areas; this is further prompted the Ministry of Trade and Industry (DTI) in the UK, with collaboration from the building sector to finance researches in order to establish and assess the risks of climate change patterns on buildings and real estate. Consequently, they will be able to identify measures and regulations to protect the building sector from the risks of climate change scenarios—especially flooding. Furthermore, raising awareness amongst professionals in the building sector is important for the potential risks emerging from climate change and the need to comply with building regulations (UKCIP, 2003).

Governments started to take the risks of flooding on the building sector seriously into account, especially in the development planning processes, where there are guiding principles and regulations for development projects in flood-prone areas (Gardiner, 2014). Furthermore, the risks from floods on buildings and real estate become much clearer, along with awareness of the extent and seriousness of such risks. Hence, regulators have realised the need to take the risks of flooding on building and real estate in greater earnest. This could incur more indirect regulation risks on the building sector, including strict regulations in relation to flooding risks (Hertin *et al.,* 2003). Importantly, stringent regulations could hamper development in the building sector and cause delays in projects: for example, based on interviews carried out by Hertin *et al.,* (2003), the permits of building and planning have been frequently refused in the UK due to the risks of floods and their effects on the building sector.

10.4.3 Stringent Regulation in Relation to Overheating Stress

Heating and cooling is used in buildings and real estate to provide a suitable and comfortable environment for occupants by using all type of energy in the building sector (Graves and Phillipson, 2000). Moreover, however, the climate change patterns affects the internal environment of buildings and real estate and result negatively on the occupants, especially in the cases of extremes changes in temperature (Roaf *et al.,* 2009). Thus, the regulators have pay attention and focus on overheating problems in the building sector, as it is considered as significant problems threaten the internal environment of buildings and real estate. Recently, this encourage the regulators to focus and consider the building regulation that related to thermal performance in the buildings sector in order to update certain stander and find new solutions including regulations (Gardiner, 2014). According to Hertin *et al.,* (2003), who declared that the need to higher regulation against overheating stress would be one of the potential indirect regulation risks which influencing the building sector.

For instance, in the United Kingdom, there are many claims to amend the regulations and standers in relation to overheating and insulations in buildings and real estate in order to comply with the potential risks of climate change scenarios. Likewise, in Germany and the Scandinavian countries are given the regulation in relation to insulation and overheating higher priority rather than other regulations (Roaf *et al.,* 2009).

10.4.4 Stringent Regulation in Relation to Windstorms Stress

The expected increase in windstorms will lead to increased probability of building exposure to more risks, which impacts the operation of such buildings, as well as adversely affecting the safety and health of occupants. This requires urgent solutions in building regulations in relation to risks from climate change in particular. Thus, these regulations will help to adapt these buildings with the surrounding circumstances and unexpected phenomena (Gardiner, 2014). According to Steenbergen *et al.,* (2012), there is then a need to consider the building regulations in line with the future trends in windstorms speed and their impacts on the building sector. In the same vein, Hertin *et al.,* (2003) claim that it is expected that the building sector will face greater regulation risks, including stringent regulations in relation to windstorms. This regulation risk is recognised as an indirect risk stemming from climate change scenarios, affecting buildings and real estate.

10.4.5 Strict Limits on Greenhouse Gas Emissions

The building sector is recognised as the largest consumer of energy in many countries around the world, where the proportion of energy consumption in buildings and real estate is between 40% and 50% of the total energy output (Butler, 2008; Pérez-Lombard *et al.,* 2008; Gardiner, 2014). This results in increased the greenhouse gas emissions from buildings and real estate, with improving energy usage and reducing greenhouse gas emissions in buildings and real estate recognised as the most important task in the building sector (Nik and Kalagasidis, 2013). In the same vein, according to Pan and Garmston (2012), there is a shift at an international level in both developed and developing countries in regard to the practical and serious building regulations associated with energy in the buildings sector. These efforts aim to reduce energy consumption in buildings and real estate in order to reduce greenhouse gas emissions. In the UK, plans and regulations to reduce energy consumption in the building sector have been adopted, leading to reduced greenhouse gas emissions (Graves and Phillipson, 2000). In addition, according to Pan and Garmston (2012), the UK government seeks to raise standards in building regulations associated with reducing the emissions of CO_2 through the imposition of strict regulations and standards on the building sector.

Furthermore, it is highly anticipated, especially across Europe, that the building sector will likely comply with the more stringent regulations in relation to greenhouse emissions in particular. These stringent regulations will not subside from now into the future, especially in relation to reducing greenhouse gas emissions, which are recognised as the main cause of global warming (Bosteels, 2013). There experiments indicate that buildings aligned with strict regulations regarding energy consumption in the building sector have resulted in positive outcomes, reflected in the reduction of greenhouse gas emissions. This shows that such regulations may be more stringent in the future, based on the impact of climate change risks on buildings and real estate (Chow and Levermore, 2010).

10.4.6 Mandatory Climate Change Risk-appropriate Building Regulation

The rise in risks of climate change patterns on the building sector may lead to the instability and stability of building regulations, with such regulations potentially needing to be updated on a regular basis in order to cope with the potential risks emerging from CCS.

According to Gardiner (2014), the government plans to adopt long-term measures in the building sector in an effort to reduce the risks of CCS on buildings and real estate, which may prove insufficient in some circumstances. This leads to the emergence of calls to amend the building regulations based on climate risks. Moreover, governments recognise that it is very important to ensure that building regulations are in line with the potential risks of climate change patterns on buildings; otherwise, there will be no opportunity to apply such regulations. In addition, there is a need to adopt realistic building regulations based on the severity risks of climate change patterns on the building sector (Huovila *et al.*, 2007): for instance, the UK government is considering and pursuing regulations that directly consider the impacts of CC so as to ensure the compatibility of such regulations with the potential risks of CC and the ability to achieve the desired goals of such adopted regulations (CCRA, 2012).

10.4.7 Uncertainty of Pending Legislation on CC

The urgent need to modernise building regulations based on the potential changes in the risks of climate change could lead to the uncertainty of such regulations. Many sectors and companies need to clear regulations associated with the risks of climate change scenarios (Latham and Watkins, 2010). This helps to avoid many mistakes and accordingly to build strategies on a sound footing—especially in the building sector. Based on UK Climate Impact Programme (UKCIP, 2003), which points out that climate change scenarios could lead to many changes in the building sector, further research and investigation is needed in order to comply with such changes.

According to Robertson (2013), it is crucial to ensure the clarity of building standards and regulations, as implementation could lead to the success of plans of resistance to the risks of climate change on buildings and real estate.

10.5 Summary of this Chapter

Emerging regulatory risks on the building sector may vary depending on the type of risk occurring and affecting buildings and real estate. These regulation risks are strict and binding from governments and regulators, with the aim of avoiding further damages from risks of climate change scenarios on the building sector.

Moreover, there are also further regulatory risks arising from a lack of certainty of such building regulations associated with the impacts of climate change patterns. This will result in an atmosphere of tension and instability in the building sector. The complete, Table 10.1 showed the summary of this chapter including issues learned, argumentations, research gap and research questions. Moreover, identified regulation risks emerging are summarised in Table 10.2 below.

Issues Learned from the Literature Review	Argumentations	Research Gaps	Research Questions
What are the type of regulation risks that emerging from CCS and affect the building sector?	As per the literature review discussed in this chapter, the regulation risks are related to other kind of emerging risks that effect buildings and real estate.	There is a need to clarify the importance of regulations in the building sector.	What is the association between CCS and regulations in the building sector?
How can the interaction between building regulations and CCS assist in uncovering the potential regulation emerging risks?	As discussed in the literature review of this chapter, there is a conflict in clarifying the relationship between CCS and building regulations; However, there is an agreement about the effect of CCS on building regulations, which will rise the needs to development and changes in regulations.	There is a need to establish the drivers of the emergence of regulation risks.	What is the suitable way to identify the emerging regulation risks and their occurrence timeframe?

Table 10.1 The Issues Learned from the Literature of Regulatory Risks

		Emerging Risks identified	Reference
Regulatory Risks	**1**	Stringent regulation in relation to water stress	CCRA (2012); Bertocchi *et al*., (2011); Graves & Phillipson (2000); Hertin *et al*., (2003); UKCIP (2003).
	2	Stringent regulation in relation to flood stress	Hertin *et al*., (2003); UKCIP (2003); Graves & Phillipson (2000).
	3	Stringent regulation in relation to overheating stress	Gardiner (2014); Hertin *et al*., (2003)
	4	Stringent regulation in relation to windstorms stress	Hertin *et al*., (2003); Graves & Phillipson (2000);
	5	Strict limits on greenhouse gas emissions	Nik & Kalagasidis (2013); Bosteels (2013); Pan and garmston (2012); Knobloch & Leurig (2010).
	6	Mandatory climate change risk-appropriate building regulation	Gardiner (2014); (CCRA, (2012); Huovila *et al*., (2007).
	7	Uncertainty of pending legislation on climate change	Robertson (2013); (UKCIP, 2003).

Table 10.2 The List of Identified Emerging Regulatory Risks

CHAPTER 11: Climate Change Risk Management (CCRM)

11.1 Introduction

The risks from climate change on buildings and real estate are recognised as one of the most challenging aspects facing building sector policy makers. According to Hertin *et al.*, (2003), through many sectors, the risks of climate change remain a key factor influencing the associated strategic decision-making. However, the risks from climate change scenarios are considered as long-term impacts, which require long-term planning and strategies (LIU, 2010) in order to cope with such climatic risks, especially in the building sector. Therefore, risk management, in terms of mitigation and adaptation strategies related to the risks from climate change (Lisø, 2006), are being addressed on a global scale. Hjerpe and Glaas (2012), state that the conversion from climate change risk analysis to assessing and managing such risks arising from climate change remain in their infancy, and requires more research. These types of research assist in reaching a comprehensive understanding of this transformation, as well as developing practical methods in the management of these risks emerging from climate change. According to Hazelwood (2014), it is vital to support and encourage the partnership between academics and partners in the building sector (including designers, owners, operators, engineering consultants, and investors) in order to assist decision-makers with the challenge of managing climate change risks within buildings and real estate.

Risk management approaches for potential risks of climate change are extremely diverse, as reflected in the presence of a wide range of decisions and legislations aiming to manage such risks in effective ways (CCRA, 2012). This leads to making buildings and real estate more resilient with different risks and impacts of climate change facing them (Hazelwood, 2014).

This chapter will review the concept of risk management in climate change risk from a building sector perspective. Moreover, the risk management process will be reviewed in order to establish the possible climate change risk management factors (including strategies, process and planning), all of which will assist buildings and real estate in coping with climate change risks.

11.2 Risk Management Concept

It is necessary to clarify exactly what is meant by risks management in relation to risks of climate change on the building sector. Generally, as based on Longman Dictionary (2014), risk management can be defined as *'a system to prevent or reduce dangerous accidents or mistakes'*. Moreover, in the Oxford Dictionary (2014), it is defined as *'the forecasting and evaluation of risks together with the identification of procedures to avoid or minimize the impacts'*. In addition, the US Presidential Congressional Commission (PCC, 1997) defines risk management as *'the process of analysing, selecting, implementing, and evaluating actions to reduce risk'.* Furthermore, Lisø (2006), cited in ISO (2002), notes risk management as being known as *'coordinated activities to direct and control an organisation with regard to risk'*.

From a building perspective, risks management related to the risks from climate change can be used to refer to *'the systematic process of using administrative decisions, organisation, operational skills and capacities to implement policies, strategies and coping capacities of the building sector to lessen the risk from the impacts of climate change'* (Hallett, 2013). Furthermore, risk management is the process of application and managing risks in accordance with the systematic method sequential serial, including several determinants, such as identification, analysis, evaluation and risks review (Australian Greenhouse Office, 2006).

According to the UK Climate Impacts Programme (2003), managing the risks resulting from climate change scenarios are recognised as a vital and crucial issue in coping with climatic risks in the buildings sector. This requires determining successful decisions and strategies by accessing the link between properties of climatic risks and the extent of vulnerability of buildings and real estate.

11.3 Climate Change Risk Management (CCRM) in the Building Sector

Studies and research show that climate change risk management is at the beginning of its inception and evolution (Knobloch and Leurig, 2010; Travis, 2014). Managing risks associated with climate change is a comprehensive approach in terms of dealing with the risks resulting from climate change in order to adapt to and cope with such risks (Jones and Preston, 2011). According to Travis (2014), the CCRM is the integration process of knowledge and information relating to the projected scenarios of climate change in an effort to make decisions leading to limited damage on buildings and real estate. Moreover, a practical approach of climate change risk management is based on three key determinants, namely the systematic use of climate information, the use of technology reducing the extent of vulnerability to risks of CC, and the adoption of legislation to help transferring risks (Hansen *et al.,* 2007). In addition, Field *et al.,* (2012), describe CCRM as *'the processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, resilience, and sustainable development'*. In addition, climate change risk management in the buildings sector aims to reduce the vulnerability of buildings and real estate, and to ensure sustainability by following and applying flexible methods to manage such risks from climate change (Lisø, 2006).

It can be stated that CCRM in the buildings sector need to follow a structured approach to reach strategic goals within practical legislation. These legislations include three types of climate change risk management, which are climate change risk management strategies, including mitigation and adaptation, operations and strategic plans. These three parameters in the CCRM aim at reducing the severity of the effects of climate change on buildings and real estate, and also circumventing their facilities' disruption and downtime. The next section of this chapter will investigate these three categories of CCRM in order to establish the most modern effective key factors for CCRM from a building perspective.

11.4 Climate Change Risk Management (CCRM) Factors

The whole purpose of climate change risk management is to identify problems so that action can be taken to eliminate or mitigate their impacts on buildings and real estate. According to Kunreuther *et al.,* (2013), the principal objective behind adopting climate change risk management is to determine and evaluate the risk management strategies in order to respond to uncertain risks of climate change. Field *et al.,* (2012), further point out that it is difficult to eliminate the potential risks from climate change on buildings and real estate; however, CCRM assists in increasing the capacity of adaptation and mitigation with the potential negative effects of climate change, as well as reducing the extent of vulnerability. Furthermore, interdisciplinary methods in CCRM in the buildings sector will increase the ability of buildings and real estate to deal with and manage the potential risks stemming from climate change; these become a key foundation for coping with the impacts and challenges from climate change in the building sector (Lisø, 2006).

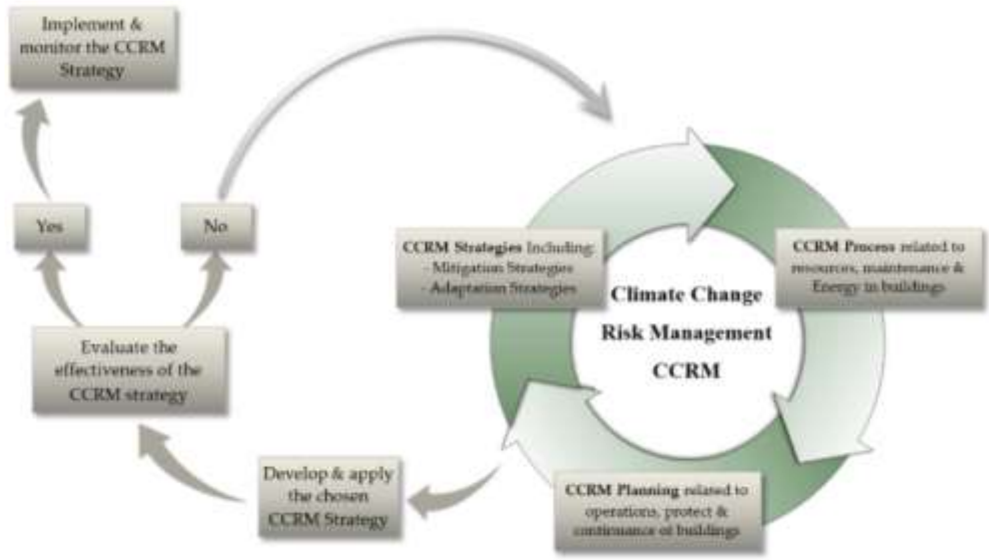

Figure 11-1 The CCRM cycle in the Building Sector;

Modified from Travis (2014) cited (Willows and Connell, 2003) and the U.S. National Research Council (2010).

Climate change risk management can be divided into three groups in order to establish the effective risk management factors related to climate change risks on buildings and real estate. These clusters are risks management strategies, process and planning, as illustrated in Figure 11-1 above. According to Figure 11.1, the process selection of CCRM methods begins by selecting the type of approach assisting buildings and real estate in avoiding or coping with the potential risks emerging from climate change. Built on this, the chosen method is developed and applied, ensuring it is in line with the characteristics of the buildings and real estate; this can be established by testing the effectiveness of the method in coping with risks and avoiding the disruption of buildings and real estate. The next stage is applied, with a follow-up adopted with continued development for the CCRM method. The reverse of this is returning to the circle of CCRM to choose another method that is more effective.

The following part of this chapter will review the potential effective climate change risk management factor.

11.4.1 Risk Management Strategies

The climate change risk management strategies include two main categories, namely adaptation and mitigation strategies. According to Kunreuther *et al.*, (2013), climate change risk management strategies play a vital role in supporting the development of CCRM policies and methods to avoid the risks from climate change; therefore, CCRM strategies are designed and implemented in such a way so as to deal with the uncertainties of climate change risks and the potential impacts on buildings and real estate. In addition, adaptation and mitigation strategies play a pivotal and key role in CCRM in the buildings sector. These strategies include a coherent and comprehensive strategies and solutions for the potential risks of climate change on buildings and real estate (Planning and Climate Change Coalition - PCCC, 2012).

The indirect risks stemming from climate change on buildings and real estate are sources of concern and fear for most sectors and organisations. These concerns are owing to the uncertainty of these risks, such as those related to regulations; this requires quick remedial measures to protect buildings and real estate from direct and indirect impacts of climate change risks. Therefore, this contributes to increasing the adaptation level of buildings and real estate, and assists them in continuing in most circumstances, as well as becoming viable both practically and commercially (Hertin *et al.,* 2003). Based on this, the property portfolio CCRM can be considered as adaptation strategies in the building sector. The present anticipations of increased frequent appearance and threats of climate change scenarios, such as floods and storms, are known to cause several climatic risks, which, in most circumstances, fall outside control limits or expectations. Consequently, there is a clear and crucial need for the existence of adaptation planning to manage such risks (Rosenzweig *et al.,* 2011). Furthermore, from the perspective of the building sector, adaptation planning is feasible by adopting adaptation action plans, which will serve as an approach to adapting buildings and real estate facing potential risks of climate change.

Generally, the building sector requires adaptation to the threats of climate change risks, especially infrastructure, which is fundamental to adapting to be more flexible in facing potential risks from climate change (Gardiner, 2014); this will reflect on the buildings and real estate. According to the Royal Academy of Engineering (RAE, 2011), infrastructure needs to be compatible with the requirements and standards of adaptation with climate change risks, leading to suitability for the harsh climatic conditions of climate change and the subsequent risks and negative impacts on infrastructure.

Rosenzweig *et al.,* (2011), claim that it is crucial to consider adaptation technology, such as materials science, monitoring and operation systems, in terms of managing risks from climate change in the buildings sector. One of the adaptation technologies is monitoring energy consumption within buildings and real estate. According to Morton *et al.,* (2011), the strategy to improve energy efficiency within buildings and real estate should be implemented in order to reach both targets: reduce carbon emissions (CO_2) and reducing energy consumption in the building sector. In addition, increasing energy consumption in buildings and real estate will increase the emissions of environmentally harmful gases, such as carbon dioxide, which leads to attention being directed towards the potential damage of such emissions and raising awareness about the risks. As a result, there is a need to establish new tools to manage such risks and result in mitigating greenhouse gas emissions (Gill *et al.,* 2004). Equally important, the United Nations Environment Programme (UNEP, 2014) indicates that the building sector is the largest contributor to greenhouse gas emissions (GHG), where building and real estate sectors consume almost one-third of the world's output of energy. Thus, energy efficiency in the building sector should be improved through Facilities Management (FM), which includes operations and plans contributing to developing buildings and real estate. These improvement processes include the use of desirable eco-methods, along with restructuring the construction or maintenance method of property.

Clearly, the FM control GHG emissions from buildings and real estate through the methods and roles adopted in order to manage and operate facilities, with facility management strategies developed in order to improve buildings and real estate. This will positively result in reduced GHG emissions from the building sector.

According to Krebs *et al.*, (2010), from an adaptation and mitigation strategies perspective, it is crucial to include the following measures when seeking to enhance buildings and real estate, as well as related work in different climatic circumstances, such as flood and storms:

- Develop plans to ensure the continuity of work within real estate in such climate conditions,
- Mitigation plans in the event of severe disturbances of supply chain, and
- Improve preparedness for facing anticipated climate change risks.

For instance, the building sector in the UK plays a vital role in protecting buildings and real estate from the negative risks of climate change, which are related to the disruption of business and supply chains in particular through implementing various building legislation and planning policies (CCRA, 2012).

The buildings sector is highly vulnerable to very different risks of climate change scenarios; therefore, the buildings sector in terms of risk management of the potential risks of climate change should be aware of and consider different strategies in order to avoid, adapt to and even mitigate these risks on buildings and real estate; thus, implementing mitigation and adaptation strategies play a vital role in protecting buildings and real estate, and in ensuring the continuation of their business and facilities operations. There are other CCRM measures centred on managing risks from climate change on buildings and real estate, such as the risk management process. The following illustrates the appropriate risk management process factors.

11.4.2 Risk Management Process

The availability of resources and related process, such as scheduling and monitoring their usage effectively, is a huge challenge for the building sector (O'Brien *et al.*, 2006), with these sources negatively influenced by risks of climate change and causing disruption to buildings and real estate or operations of such property. Moreover, adopting and implementing adaptation measures with the risks of climate change may include some risks, such as the unnecessary use of resources, which is why there must be a balance of resources through balancing the level of perceived risks of climate change with the options of appropriate adaptation (Willows and Connell, 2003).

According to Australian Greenhouse Office (AGO, 2006), regulated resources and their availability within any organisation (such as the building sector) facilitate access to potential risks, and are also considered as one of the climate change risks management treatments centred on coping with and adapting to the impacts of various climate change risks.

It is clear that the availability of resources, along with balancing resources, is one of the processes of CCRM in the building sector, which is an approach concerned with working on ensuring the continuation of general business and operational processes that require different resources in buildings and real estate. The availability of resources gives strong support for buildings and real estate in facing different circumstances of climate change scenarios and overcoming their different impacts and risks.

The exposure of buildings and real estate to the extreme climate change events, such as storms and flooding, will lead to increased damage to property; thus, periodic maintenance and repair will be required, especially for old existing premises and historical buildings

(LCCP, 2002). In addition, for instance, heavy precipitation that impacts buildings and real estate leads to further requirements for maintenance to protect property from the dangers of breakthroughs rainwater to buildings. This frequent maintenance leads to ensuring that buildings and real estate perform as designed, and are constructed throughout their lifespan as expected (Graves and Phillipson, 2000). Therefore, considering the periodic maintenance scheduling in the building sector will assist buildings and real estate in dealing with the risks from climate change and will result in the success of climate change risks management. According to Graves and Phillipson (2000), periodic maintenance for buildings and real estate extremely help in determining the vulnerable placement in property to the impacts of climate change risks; this also leads to reducing the extent of risks emerging from climate change on buildings and real estate, along with reducing its spread to other parts of property.

There is another process of CCRM in the building sector, which is implementing and using renewable energy in order to reduce emissions of GHGs and to avoid potential risks emerging from climate change scenarios. According to Eisentraut and Brown (2014), the use of energy related to CO_2 emissions in the building sector will increase two-fold in 2050; this will increase the probability emergence of climate changes scenarios and their impacts on buildings and real estate. Consequently, it is time to implement the use of renewable energy in the building sector in order to overcome the risks resulting from climate change—especially those relating to the use of energy. In addition, in terms of climate change risk management, Halsnæs *et al.*, (2014), indicate that the use of renewable energy is one of the vital options in policies and measures of mitigating the risks of climate change risks. The development of energy efficiency and the use of renewable energy potentially achieves many benefits, such as reduced pollution, developed services and improved sectors. For instance, according to Missaoui and Mourtada (2010), recently, there are claims to the International Energy Agency (IEA) to create and establish a network of sustainable buildings focused on developing practical tools and measures for the implementation of energy efficiency and the use of renewable energy in buildings and real estate. Furthermore, the increased use of renewable energy in the building sector leads to establishing effective solutions for the challenges inherent in energy efficiency and availability; these will result in limiting the risks emerging from climate change on buildings and real estate (Eisentraut and Brown, 2014).

It is clear that the risk management processes under CCRM are as important as mitigation and adaptation strategies in the building sector. These processes are direct and related, and control the operation processes in buildings and real estate, such as through the availability of resources and maintenance. These processes in climate change risk management are potentially effective in facing climate change risks and reducing their severity on buildings and real estate.

11.4.3 Risk Management Planning

The risk management planning is approach which concerned with following stages or steps during long periods of time in order to manage the risks of climate change successfully and effectively. According to PCCC (2012), the local plans in the building sector need to reflect positively in the adaptation of buildings and real estate, with consideration to different risks of climate change. These plans of risk management will ensure the effective management of emerging risks from climate over the long-term.

One of these risk management planning is disruption planning, which is also known as emergencies planning. According to Krebs *et al.,* (2010), disruption planning assists in reducing the impacts of potentially different climate change risks. The effectiveness of disruption planning is through focusing on and considering the climate predictions for potential disasters and extreme climatic events, such as storms and floods. This helps buildings and real estate in terms of business continuity, and avoids disruption—even in circumstances of impact of other indirect risks, such as the disruption of supply chains. For instance, in the events of flooding, the transportation sector applies emergency plans, including increased ability of drainage and processing back-up equipment for such conditions; this will result in maintaining services during storms (Rosenzweig *et al.*, 2011). Similarly, for the buildings sector, effective disruption planning leads to protecting buildings and real estate from the risks emerging from climate change, and increases the efficiency of their resistance to climatic conditions and extreme events, along with the maintenance planning for the facilities and operations in buildings and real estate. Sapp (2013), declares that the maintenance plans in the buildings sector include a large number of scheduled processes and operation plans, all of which help to ensure that buildings and real estate perform in different climatic circumstances and conditions the intended functions designed and constructed. In addition, the processes and operation need to ensure the provision of safe and suitable environment for occupants in usable buildings and real estate (Gardiner, 2014).

Equally important in the management of climate change risks in the building sector is resources planning, which ensures the optimal use of resources, such as energy, water and requirement resources for operations. Resource planning also enhances the availability of resources under different effects of climate change risks on buildings and real estate (Willows and Connell, 2003).

Furthermore, Krebs *et al.,* (2010), claim that, in terms of the risk management planning of climate change risks, emergency plans should include the financial stress resulting from risks emerging from climate change. Financial stress plans help to avoid economic losses and accordingly enhance the opportunities from climate change scenarios.

According to Grossman (2012), cited in other works, such as KPMG (2008), climate change risk management—which includes financial plans—helps sectors and institutions to determine the types of risk, which leads to controlling the effects and implementing a suitable plan to avoid such risks; however, there are various financial risks that cannot be avoided, such as increased demand in the market, which needs to advance long-term planning in order to reduce severity.

Correspondingly, in the buildings sector, there need to be contingency plans to contain the various economic pressures, such as the rising prices of resources and services resulting from the risks of climate change. Moreover, financial plans should be devised deal with potential changes in market demand, such as the availability of appropriate buildings, especially in the areas under the threats of climate change risks, as well as availability of resources and materials in the building sector.

Emissions in the building sector have two main risks contributing to the causes of climate change and environmental pollution, meaning controlling these emissions is one of the goals of CCRM in buildings and real estate. Based on the work of Missaoui and Mourtada (2010), improving energy use in buildings and real estate, especially in the equipment of cooling and heating, greatly helps to increase energy efficiency and to reduce carbon emissions in the buildings sector. Moreover, adopting plans to improve equipment in the building sector, such as changing habits in the use of alternative fuels and facilitating the development of electricity supply will have a significant role in terms of reducing the emissions of GHGs (Morton *et al.,* 2011).

Likewise, shifts in the use of renewable energy within buildings and real estate for such services including cooling and heating will also lead to cutting emissions and improving energy efficiency. For example, the building sector in France adopts energy plans and strategies centred on achieving the following goals:

- Generating renewable energy on site;

- Using a combination of different energy resources within buildings and real estate (Missaoui and Mourtada, 2010).

In addition, climate change is causing more pressure on water resources, which requires more activities and measures for the provision and management of water availability and usage in the buildings sector (Hallett, 2013). Furthermore, regulators seek to introduce measures and legislation designed to save and control water in the building sector. These measures fall within water management in buildings and real estate through considering three main elements, namely the provision of water-saving appliances, recycling water, and the imposition of restrictions on the amount of water used and consumed (Hertin *et al.*, 2003).

Accordingly, water management in buildings and real estate is essential in CCRM, as with other vital sources management. Plans of water management are very likely to be effective in facing the risks of climate change occupied in the building sector—especially the risks related to water availability in buildings and real estate, as well as water discharge. Water discharge might fall under waste management plans. According to UKCIP (2003), waste management plans in the building sector help to prevent increased contamination risk, which is negatively affected by various climate change scenarios, such as rainfall and flooding. Consequently, the effective plans of waste management lead to increased ability for the sectors to cope with the risks stemming from climate change and to reduce the severity of such risks. Waste management plans include waste collection, disposal and recycling, with each of these plans leading to a reduction in pollution from buildings and real estate, thus reducing emissions of GHGs.

11.5 Summary of this Chapter

The risks of climate change on the building sector are versatile and unclear; therefore, Jones and Preston (2011), indicate that CCRM in the building sector operates with a degree of focus on probability and the occurrence of these risks and their impacts on property. CCRM aims to contain the potential risks from climate change on buildings and real estate within strategies, process and plans to mitigate and adapt to such risks emerging from climate change. These CCRM factors assist the building sector in coping with such emerging climatic risks and controlling their severity and impacts in a practical and effective way. In short, Table 11.1 below presented the main findings from the literature review of this chapter along with the full identified climate change risk management factors, which summarised in Table 11.2 below.

Issues Learned from the Literature Review	Argumentations	Research Gaps	Research Questions
What is the risk management in relation to CC?	As per the literature review discussed in this chapter, the CCRM is new technique and method to deal with risks emerging from CCS.	There is a need to clarify the concept of CCRM in the building sector.	How to find and assess the relationship between the theory of risk management and CCS?
Is there mapping that assist professionals and practitioners in the building sector to avoid or to cope with either existing or new buildings with potential risks from CCS?	As literature review discussed, there is no clear strategies in order to manage CCR and cope buildings with such emerging risks.	There is a need to investigate the practical way of identifying and grouping CCRM.	What is the effective CCRM factors that assist in mitigation and adaptation process?
How can quantify climate change risk management in relationship with the emerging risks from CCS?	As discussed in the literature review of this chapter, the CCRM can be identified and clustered from/in three different manner.		How to measure the effectiveness of CCRM strategies?

Table 11.1The Issues Learned from the Literature of Climate Change Risk Management

		Risk management factors	Reference
Climate Change Risk Management	**1**	Disruption planning	Gardiner (2014); Rosenzweig *et al.*, (2011); Krebs *et al.*, (2010)
	2	Balancing resources	O'Brien *et al.*, (20006); Willows & Connell (2003)
	3	Stand-by-preparation	Krebs *et al.*, (2010)
	4	Maintenance planning	Sapp (2013)
	5	Operations planning	Gardiner (2014); Sapp (2013)
	6	Resource planning	Willows & Connell (2003)
	7	Maintenance scheduling	LCCP (2002); Graves and Phillipson (2000)
	8	Adaptation planning	Gardiner (2014); Rosenzweig *et al.*, (2011)
	9	Property portfolio climate change risk management	Hallett (2013); CCRA (2012); Hertin *et al.*, 2003
	10	Financial stress emergency plans	Krebs *et al.*, (2010);
	11	Development of new compliance infrastructure	Gardiner (2014); RAE (2011); Hertin *et al.*, 2003
	12	Mitigation plans for disruption to business processes	Krebs *et al.*, (2010)
	13	Plans to deal with changes in market demand	Grossman (2012)
	14	Mitigation plans for disruption to supply chain	Hallett (2013); CCRA (2012); Krebs *et al.*, (2010)
	15	Availability of resources	O'Brien *et al.*, (20006); AGO (2006)
	16	FM strategies to improve properties to reduce emissions	UNEP (2014)
	17	Plans to improve equipment to reduce emissions	Morton et al., (2011); Missaoui and Mourtada (2010)
	18	Plans to manage water footprint	Hallett (2013); Hertin *et al.*, 2003
	19	Plans to use adaptation technology	Rosenzweig *et al.*, (2011)
	20	Strategy to improve energy efficiency	Hallett (2013); Morton *et al.*, (2011); Gill *et al.*, (2004)
	21	Increasing use of renewable energy	Halsnæs *et al.*, (2014); Missaoui & Mourtada (2010)
	22	Plans to generate renewable energy on site	Missaoui & Mourtada (2010)
	23	Water management mitigation plans	Hallett (2013); Hertin *et al.*, 2003
	24	Waste management plans	UKCIP (2003)

Table 11.2 The List of Identified Climate Change Risk Management

CHAPTER 12: FINDINGS AND DESCRIPTIVE ANALYSIS

12.1 Introduction

As has been explained earlier on in the research methodology (Chapter 2), this research project conducted a survey in order to achieve the aims and objectives. Built on this, a questionnaire was created and developed, comprising 143 questions, including 136 questions relating to the risks factors emerging from climate change scenarios, categorised into 8 groups, as shown in Figure 12-1 below; along with 7 questions concerning general information about the participants. The target group in this study included consultants, specialists and engineers, such as architects, constructors, risk managers, project managers and environmental managers, all of whom work in facilities management or real estate services in various organisations, such as universities, hospitals and housing associations in the UK.

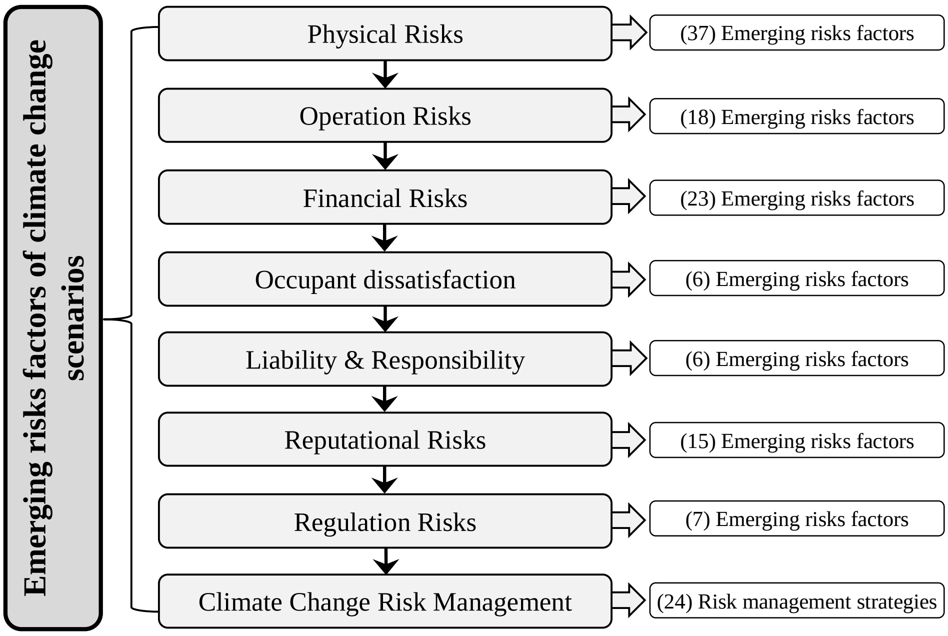

Figure 12-1 Structure of the Questionnaire Clusters

In this study, the questionnaire was electronically circulated via email to the participants in organisations or institutions. This chapter will analyse and illustrate the response, which will be reviewed in this part of the research project, and will describe and present the reached results from this study, along with the methods of analysing the factors of risks emerging from CCS on the building sector.

12.2 Questionnaire Findings

This part will describe and illustrate the overall results of the questionnaire, and then will discuss and explain them in greater detail. As illustrated above, the questionnaire was circulated amongst sectors and organisations in the UK. The response rate in this study was 23%, where 78 of the respondents returned a valid and completed questionnaire; this was of 340 of total participants. The following part will present the findings from the general questions.

12.2.1 Descriptions the General Information of Respondents

As mentioned, the survey included questions pertaining to ascertaining general information about the respondents. These questions began with the type of organisation; second, questions were asked regarding the participants' role in their organisations; the third question centred on the experience of the organisation in managing and assessing the risks emerging from climate change; the fourth question asking about the number of buildings that under the responsibility of the organisations; the fifth question concerned the extent to which the organisations' buildings need adapting to the risks of climate change; the sixth question centred on whether the organisations have guidelines in terms of assessing and managing the emerging risks of climate change; and the seventh question queried the respondents about the innovated solutions employed in organisations, and whether these are developed to adapt to the building's risks of climate change; and the final question asked for respondents' emails, and was considered an optional question.

The findings from the general information about the respondents of this study and their organisations are presented and discussed in the following section of this chapter.

12.2.1.1 Respondents' Organisations Type

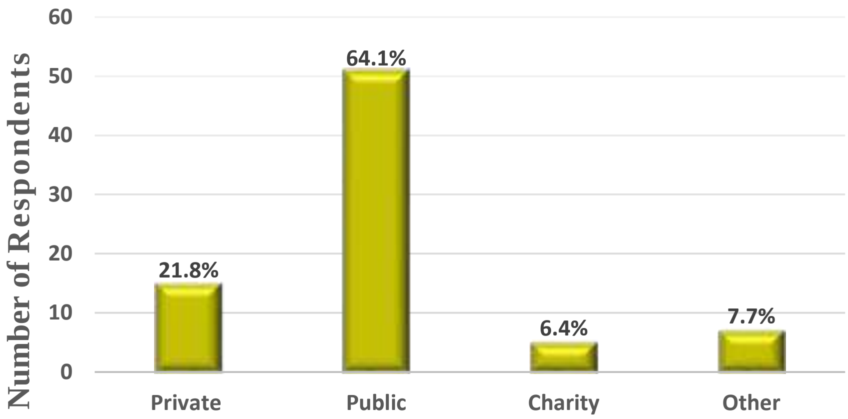

Figure 12-2 Respondents' Organisations Type

This part illustrated the answers of the respondents concerning the type of organisation by which they were employed. Figure 12-2 above illustrates that the majority of the respondents were from the public sector, which represents 51, equating to approximately 64% of the total number of respondents. From the private sector, respondents amounted to 15, which is about 21.8% of the total respondents; this was followed by the charity sector, represented by only 5 (6.4% of the respondents). Moreover, seven of the respondents (7.7%) were represented by other sectors. As seen, the largest respondents are employee in the public and private sector, representing 85.9% of the sample size. The respondents present the point of view of their organisation, sector and institution.

12.2.1.2 Respondents' Professional Role

Professional role	Facility Manager	Risk Manager	Real estate's Portfolio Manager	Owner	Academic	Other	**Total**
Number	22	9	6	1	3	37	**78**
Rate	28.21%	11.51%	7.70%	1.30%	3.85%	47.44%	**100%**

Table 12.1 Respondents' Professional Role

The findings from this part, as shown in Table 12.1 above, summarise the respondents' role within their organisations. Most of the respondents went with the choice of 'other', as shown by 37 respondents (47.44%). This professional role includes several functions, such as sustainable manager, environmental manager and energy manager, as based on respondents' answers to the survey. In the second place was the facility managers, with about 22 (28.21%) of the total respondents, with risk managers amounting to 9 mangers (11.51%). This was followed by real estate portfolio managers totalling 6 managers (7.70%). A select few of the respondents were considered academics, amounting to 3 (3.85%). Moreover, only 1 (1.3%) of the respondents represented the owner's role. The Figure 12-3 below shows the overall classification of respondents' role within their organisations.

Figure 12-3 Description of Respondents' Professional Role

It appears that the other professional roles of respondents presented various types of professional role, along with that considered by the study. Moreover, this will be considered by the study in an effort to investigate the difference in professional roles and how this can reflect assessing the emerging risks in terms of occurrence and emergence timescale, as well as the effectiveness of CCRM.

12.2.1.3 Experience of Respondents' Organisations

The survey shows that 56 (72%) of the 78 respondents indicate that their organisations have experience in assessing and managing the risks emerging from climate change scenarios on their buildings and facilities. Around 22 (28%) of the respondents claimed that their organisations do not have experience in this field, as shown in Figure 12-4 below. It is clear that the majority of the organisations or sectors have experience in regards to the CCR; this might be considered one of the validation points of this study.

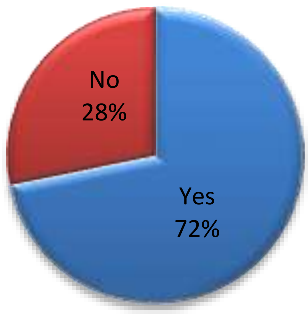

Figure 12-4 Experience of Respondents' Organisations in Emerging Risks from CCS

12.2.1.4 Total Buildings under Organisations Responsibility

Based on the Figure 12-5 below, the study determined that more than half of the respondents (63; equating to 81%)—which is the majority of the respondents—work for organisations that are responsible for more than 20 buildings. Moreover, 7 (9%) of the respondents declared that they are employed by organisations with less than 5 buildings under their management, whereas only 4 respondents (5%) of the 78 respondents indicated that 11–20 buildings are under their organisation's responsibility. Importantly, an equal number and rate of respondents went with the choice of 6–10 buildings.

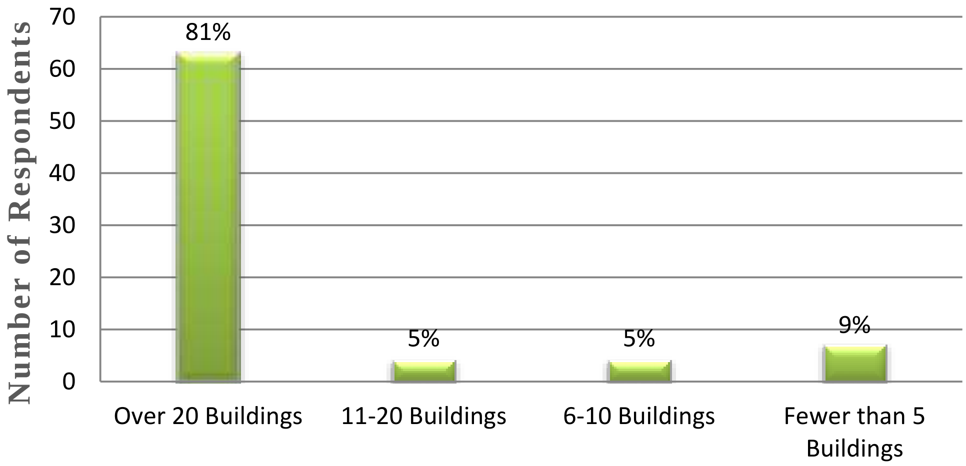

Figure 12-5 Number of Buildings Under Organisations Responsibility

It is notable that the large majority of organisations and sectors involved in this study have more than 20 buildings under their management; this is considered a strong support in regards to the validation of the study.

12.2.1.5 The Adaptation Level in Organisations' Buildings

The findings show that 40 (51%) of the respondents indicated that the current buildings are in need of being adapted to the risks of climate change on an average level of adaptation; according to 29 (37%) of the respondents, the current stock of their buildings and real estate need to be above average, as seen in Figure 12-6.

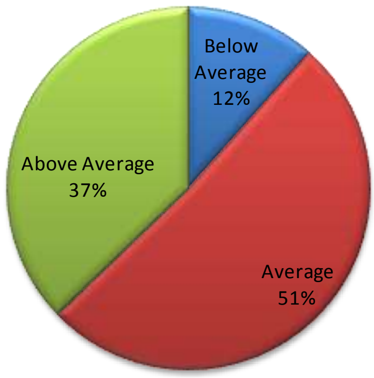

Figure 12-6 The Extend of Buildings' Adaptation to CCR in Organisations

Just 9 (12%) of the sample believe that the buildings need are of lower than average need of adaptation level to climate change risks. The respondents from the organisations or sectors with more than 20 buildings under their management or responsibility described their adaptation level as follows: below average (7 = 9%), average (29 = 37.18%) and above average (28 = 35.90%).

12.2.1.6 Guidelines for Assessing Emerging Risks of CC in Organisations

Although 27 (35%) of the respondents indicate that their organisations have noted guidelines for assessing the potential emerging risks from CCS while 65% of organisations do not have guidelines for these emerging risks. More specifically, based on the respondents to the survey in the organisations that managing more than 20 buildings, only 30.80% (24 of the respondents) have guidelines in place for assessing the potential risks stemming from CCS; also approximately double of this number (51.28% = 40 of the respondents) do not have guidelines for these emerging risks.

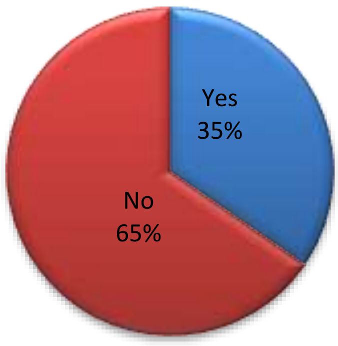

Figure 12-7 Availability of Guidelines for Assessing Risks From CCS in Respondents' Organisations

12.2.1.7 Level of Innovative Solutions in Adapting Stock Buildings

As illustrated in Figure 12-8 below, 43 (55.2%) of the respondents note that developing innovative solutions to adapt their building stock to the risks of climate change at their organisation is at an average level. Moreover, 16 (20.5%) of the respondents pointed out that the level of developing an innovation solution for stock buildings to deal with the potential risks of climate change is below average and the same rate at the above-average level. On the other hand, there are no innovative solutions, as noted by 3 (3.8%) of the respondent in their organisations.

With regard to the diversity of answers in this part, it may be that the respondents have different experiences in relation to developing innovative solutions against the risks of CCS and their impacts.

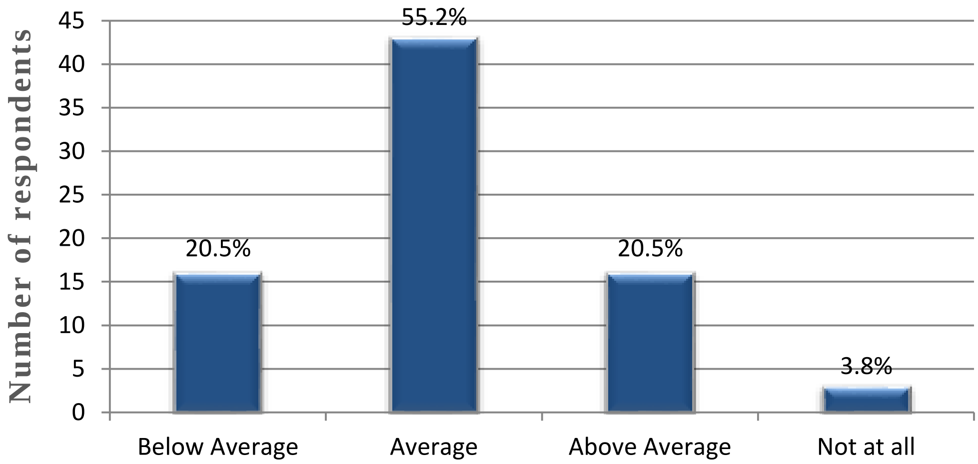

Figure 12-8 Level of Developing Innovative Solutions in Adapting Buildings

12.3 Descriptive Analysis of the Questionnaire Findings

A list of emerging risks derived from the literature was provided to the respondents of the survey. The subjects were all asked to rate each risk in terms of the likelihood of the occurrence on the buildings and real estate using a Likert scale (ranging very unlikely, unlikely, neutral, likely and very likely). Furthermore, the respondents were also asked to rate each emerging risk factor's influences as based on the timeframe of the probability of occurrence, using the Likert scale (ranging not at all, 0–5 years, 5–10 years and more than 10 years).

12.3.1 Physical Risks Factors

The factors of physical risks are based on 36 statements. Table 12.2 shows that the **PH10 'Increased capital expenditure due to physical risks'** is likely to have an effect on buildings' assets, according to 47.4% of the respondents, whilst it is very likely to have an effect according to approximately 32.1% of the respondents. Using the average effect score, which is 1.95 (rank = 1) with .866 standard deviation (SD), this factor generally has an important impact (median = 2.00) on the building sector.

The same result is observed for the statement concerned with **PH23 'Increase in the cost of materials supplies'**. Namely, this physical risk factor is likely to have an influence according to 47.4% of the respondents, whilst it is very likely to have an impact according to approximately 33.3% of the respondents. The average effect score is 1.97 (rank = 2) with an SD of .967; hence, there is importance for this emerging risk factor (median = 2) based on its potential risks on buildings and real estate.

Likewise, **PH17 'Surface water flooding'** is likely to induce impacts on buildings, as shown by approximately 52.6% of the respondents, whilst it is very likely to have an impact according to 30.8% of the total respondents. As a result, the average effect score is found to be 2.03 (rank = 3), with 1.04 standard deviation, thus meaning that there are essential physical effects (median = 2) on buildings and real estate, stemming from this factor.

The risk factor concerned with **PH9 'Potential need for retrofitting mechanical ventilation'** shows the likelihood of impacts on the building sector. According to 46.2% of the respondents, the impact becomes higher (very likely) according to approximately 36% of them. The average effect score is 2.06 (rank = 4) with .873 SD, meaning that there is generally high probability of influences on the buildings from this physical risk factor.

It is likely that the physical risks of **PH33 'Erosion of historic building fabric'** will emerge on the building sector, as shown by 50% of the respondents, whilst the impact from this risk factor might be higher according to 20.5% of the respondents. The percentage of people showing neutrality is 20.5%. The average likelihood of this physical risk score is 2.15 (rank = 5) with .839 SD indicating that there is considerable impact (median = 2) on the buildings and real estate from this risk as a result of the climate change scenarios.

The physical risk, which is **PH32 'Increase of damp, condensation and mould problems in buildings'**, is recognised as able to play an important role in increasing the physical damage on the building sector, where 51.3% of the respondents believe that the effect is likely to occur, and 41.1% of the respondents believe it is very likely to occur on buildings due to the threat of CCS, whereas 20.5% show neutrality. The average of probability effect is 2.35 with a .895 standard deviation, meaning that the impacts (median = 2) are likely to happen on buildings and real estate due to this physical risk factor.

R.F Code	Risks Factors (R.F)	Percent of scores (%)					Mean	Median	St. Deviation	Rank
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely				
		5	4	3	2	1				
PH1	Rapid asset deterioration	**7.7**	**32.1**	**23.1**	**33.3**	**3.8**	3.06	3.00	1.06	*27*
PH2	Potential for increased odour problems	**11.5**	**33.3**	**32.1**	**21.8**	**1.3**	3.32	3.00	.987	*34*
PH3	Reduced asset life	**2.6**	**16.7**	**29.5**	**46.2**	**5.1**	2.65	2.00	.909	*17*
PH4	Disposal of debris including hazardous materials (from windstorms)	**9.0**	**32.1**	**32.1**	**25.6**	**1.3**	3.22	3.00	.976	*33*
PH5	Increased fire risks	**5.1**	**26.9**	**33.3**	**29.5**	**5.1**	2.97	3.00	.993	*24*
PH6	Scour to structures (from intense rainfall)	**5.1**	**20.5**	**39.7**	**26.9**	**7.7**	2.88	3.00	.993	*23*
PH7	Cracking or melting of pavements	**9.0**	**20.5**	**23.1**	**41.0**	**6.4**	2.85	3.00	1.10	*22*
PH8	Cracking of building fabric	**2.6**	**20.5**	**20.5**	**47.4**	**9.0**	2.60	2.00	.998	*16*
PH9	Potential need for retrofitting mechanical ventilation	**1.3**	**3.8**	**21.8**	**46.2**	**36**	2.06	2.00	.873	*4*
PH10	Increased capital expenditures due to physical risks	**1.3**	**3.8**	**15.4**	**47.4**	**32.1**	1.95	2.00	.866	*1*
PH11	Reliability of mechanical and electrical services in buildings	**-**	**2.6**	**15.4**	**46.2**	**14.1**	2.46	2.00	1.00	*12*
PH12	Increasing subsidence and heave movement	**2.6**	**33.3**	**39.7**	**17.9**	**6.4**	3.08	3.00	.937	*28*
PH13	Damage to building foundation due to subsidence and heave movement	**5.1**	**32.1**	**41**	**14.1**	**7.7**	3.13	3.00	.985	*30*

PH14	Damage to building facades due to subsidence and heave movement	**5.1**	**29.5**	**33.3**	**26.9**	**5.1**	3.03	3.00	.993	*25*
PH15	Increasing soil shrinking and swelling	**3.8**	**21.8**	**25.6**	**44.9**	**3.8**	2.77	3.00	.966	*20*
PH16	Damage to underground services	**3.8**	**20.6**	**34.6**	**29.5**	**11.5**	2.76	3.00	1.03	*19*
PH17	Surface water flooding	**5.1**	**6.4**	**5.1**	**52.6**	**30.8**	2.03	2.00	1.04	*3*
PH18	Groundwater water flooding (from rising groundwater)	**5.1**	**23.1**	**11.5**	**43.6**	**16.7**	2.56	2.00	1.16	*15*
PH19	Water ingress to facades	**5.1**	**15.4**	**17.9**	**51.3**	**10.3**	2.54	2.00	1.04	*14*
PH20	Water ingress to roofs	**5.1**	**14.1**	**12.8**	**47.4**	**20.5**	2.36	2.00	1.11	*7*
PH21	Inundation of basement and ground floor	**6.4**	**15.4**	**24.4**	**32.1**	**21.8**	2.53	2.00	1.18	*13*
PH22	Vulnerability of services and plant	**3.8**	**10.3**	**23.1**	**48.7**	**14.1**	2.41	2.00	.986	*10*
PH23	Increase in the cost of materials supplies	**2.6**	**6.4**	**10.3**	**47.4**	**33.3**	1.97	2.00	.967	*2*
PH24	Saline water intrusion	**21.8**	**25.6**	**30.8**	**17.9**	**38**	3.44	3.00	1.13	*36*
PH25	Corrosive saline atmospheric exposure	**17.9**	**23.1**	**38.5**	**17.9**	**2.6**	3.36	3.00	1.05	*35*
PH26	Increase of acid rain weathering on building fabric	**5.1**	**30.8**	**32.1**	**26.9**	**5.1**	3.04	3.00	.999	*26*
PH27	Increase of defective building elements due to unforeseen weather conditions	**3.8**	**9**	**23.1**	**50**	**14.1**	2.38	2.00	.970	*8*
PH28	Extreme exposure of building shell to dust	**6.4**	**28.2**	**43.6**	**17.9**	**3.8**	3.15	3.00	.927	*31*
PH29	Increase of latent defect problems	**2.6**	**17.9**	**42.3**	**33.3**	**3.8**	2.82	3.00	.864	*21*
PH30	Damage due to high snow load on buildings	**6.4**	**39.7**	**24.4**	**21.8**	**7.7**	3.15	3.00	1.08	*32*
PH31	Damage to building assets from frost/snow	**3.8**	**19.2**	**26.9**	**39.7**	**10.3**	2.67	2.50	1.02	*18*
PH32	Increase of damp, condensation and mould problems in buildings	**-**	**14.1**	**20.5**	**51.3**	**14.1**	2.35	2.00	.895	*6*
PH33	Erosion of historic building fabric	**1.3**	**3.8**	**24.4**	**50**	**20.5**	2.15	2.00	.839	*5*
PH34	Lightning strike damage to buildings during storms	**7.7**	**30.8**	**29.5**	**28.2**	**3.8**	3.10	3.00	1.02	*29*
PH35	Slope instability	**19.2**	**29.5**	**32.1**	**16.7**	**2.6**	3.46	3.00	1.06	*37*
PH36	Insufficient roof drainage in storms	**5.1**	**14.1**	**16.7**	**42.3**	**21.8**	2.38	2.00	1.13	*9*
PH37	Decreased durability and performance of materials	**-**	**11.5**	**11.5**	**34.6**	**17.9**	2.41	2.00	.918	*11*

Table 12.2 Descriptive Statistics for Physical Risks

The physical risk **PH20 'Water ingress to roof'** is likely to induce impacts on buildings according to 47.4% of the respondents, whilst the impact is viewed as very likely to occur by 20.5 of the respondents, which is equal to 2.36 (rank = 7) with 1.11 SD. Therefore, this physical risk is considered an important emerging risk factor (median = 2) in terms of its threat on the building sector due to CCS.

Based on half of the respondents (50%), the risk factor concerned with **PH27 'Increase of defective building elements due to unforeseen weather conditions'** is likely to have an impact on buildings and real estate; the impact is likely to arise according to 14.1% of the respondents. Approximately 23.1% (about one-quarter) of the respondents show neutrality towards having an influence on buildings from this physical risk. The average effect is 2.38 (rank = 8) with .970 SD, leading to an essential effect (median = 2) potentially occurring as a result of the risk.

It is likely for **PH36 'Insufficient roof drainage in storms'** to lead to negative impacts on buildings, as shown by approximately 42.3% of the respondents, whilst the impact is very likely to occur for approximately 21.8% of the respondents. The average possibility of the impact is 2.38 (rank = 9), which is the same as the previous risk factor, but with a higher SD, which is 1.13. Generally, there are fundamental effects stemming from this physical risk (median = 2), which might be occur on buildings and real estate.

The physical risk known as **PH22 'Vulnerability of services and plant'** is likely to emerge, according to almost half of the respondents (48.7%), whereas the impact is recognised as being very likely to happen according to 14.1% of them; 23.1% of the respondents showed neutrality. The average probability of this physical risk is 2.41 (rank = 10) with .986 SD; therefore, this statement is considered an important effective factor (median = 2) resulting on buildings as a result of the risks of CCP.

Moreover, the physical risk factor of **PH37 'Decreased durability and performance of materials'** boosts the physical impacts on buildings and real estate, where 34.6% of the respondents believe that the effect is likely to arise under the threat of climate change patterns, where 17.9% of them believe that it is very likely, whilst 11.5% of them showed neutrality. The average effect is 2.41 (rank = 11) with .918 SD, which means the impact (median = 2) is likely to happen due to this physical risk.

The physical risk factor **PH11 'Reliability of mechanical and electrical services in buildings'** is expected to increase the physical effects on buildings according to 46.2% of respondents, where the effects are highly expected (very likely), as shown by 14.1% of the respondents. However, only 15.4% of the respondents were neutral. The average likelihood emergence of this risk factor is 2.46 (rank = 12), with 1.00 SD leading to a fundamental physical influence (median = 2) on the building sector.

The **PH21 'Inundation of basement and ground floor'** physical risk factor also results in increased physical effects on buildings due to climatic threat, where 32.1% of respondents consider that this factor will have an effect, with 21.8% believing it is very likely to occur. On the other hand, almost one-quarter of the respondents (24.4%) show neutrality. The average likelihood effects score is 2.53 (rank = 13) with 1.18 SD; hence, the inundation of basement and ground floor has an important potential effect (median = 2) on buildings and real estate.

The statement concerned with **PH19 'Water ingress to facades'** is found to have impacts on the building sector according to 51.3% (about half) of the respondents, whilst 10.3% of them consider the impact to be very high (very likely) to occur as a result of CCS. The neutrality of this factor is observed amongst 17.9% of them. The average possibility of the impacts of this physical risk is 2.54 (rank = 14) with 1.04 SD, and hence it is deduced that real impact (median = 2) might be inflicted by the buildings and real estate.

It is likely for **PH18 'Groundwater water floods (from rising groundwater)'** to result in impact on the building sector, as shown by about 43% of the respondents, whilst the impact is expected to become higher to impact assets, according to 16.7% of them. The percentage of people showing neutrality is 20.5%, whilst 23.1% of them consider it unlikely to witnessed effects from this physical risk. According to the resulting mean, which is 2.15 (rank = 15) with 1.16 SD, there are emerging impacts (median = 2) on the building sector in terms of physical risk.

The physical risk **PH8 'Cracking of building fabric'** is likely to increase the physical impacts on the building sector according to 47.4% of the respondents, whereas just 9.0% of them believe that the effects are very likely to occur. On the other hand, 20.5% of the respondents think that there are not any effects emerging from this risk factor. The average likelihood is 2.60 (rank = 16) with .918 SD, meaning that the impacts (median = 2) seem to be likely to happen due to this physical risk.

The **PH3 'Reduced asset life'** physical risk factor is expected to increase the effects on the building sector according to 46.2% of the respondents, but the effect is highly expected (very likely), as shown by only 5.1% of them. However, only 29.5% of them were neutral, whilst

16.7% of them do not believe in believe any effects will occur in terms of this physical risk. The average possibility impact of this statement is 2.65 (rank = 127) with .909 SD, leading to being a likely influence (median = 2) on buildings and real estate.

The **PH31 'Damage to building assets from frost/snow'** physical risk factor has been chosen as a likely emerging risk to occur on the buildings sector, as shown by 39.7% of the respondents. Whilst its impacts become more likely to arise according to only 16.7% of the respondents, the percentage of respondents showing neutrality is 26.9%, whereas 19.1% think it is unlikely that they will arise on property. According to the average effect score, which is 2.67 (rank = 18) with 1.05 SD, there is an impact (median = 2.50) likely to occur on buildings and real estate due to the physical risk factor.

It can be noted that, for the rest of the physical risks, neutrality is observed as the average score and median of effect is higher than 2.60 (likely), as illustrated in Table 12.2 above. Nevertheless, the **PH35 'Slope instability'** is the lowest physical risk factor expected to appear on buildings and real estate due to CCS, as the average likelihood occurrence of this indicator is 3.46 (rank = 37) with 1.06 SD. Moreover, the **PH25 'Corrosive saline atmospheric'** and **PH24 'Saline water intrusion'** showed an average of 3.36 and 3.44 (rank = 35 and 36), along with 1.05 and 1.13 SD, respectively.

12.3.2 Operational Risks Factors

The operational emerging risks factors consist of 18 statements. The first important risk as shown in the Table 12.3, is **OP2 'Higher energy prices'**, where the majority of respondents (80.8%) found that the effect is very likely to emerge due the effects of CCP. This was followed by approximately 16.7% of the respondents, who suggested that this operational risk is just likely to happen. The statistics using average effect score, which is 1.22 (rank = 1) with standard deviation of .474, leads to strong evidence of having a high effect (median = 1), which is likely to occur on the building sector by this factor.

Also, a large number of the respondents, represented by 74.4%, find that the operational risk **OP3 'Increasing water costs'** is very likely to have serious effects on buildings and real estate, with the effect likely to arise according to 16.7% of them. The average effect score is 1.29 (rank = 2) with .537 SD, meaning that the underlying operational risk factor has a high influence on the building sector.

The operational emerging risk **OP1 'Increase in energy use'** boosts the impacts on the building sector, where 56.4% of the respondents believe that the effect is very likely to occur due to this factor; 30.3% of them believe that the risk is likely to occur, whilst just 7.7% of them show neutrality. The average score possibility effects of this risk factor is 1.62 (rank = 3) with .841 SD, meaning the impact of the increase in energy use (median = 1) is very likely to occur due to the risks of climatic patterns.

R.E Code	Risks Factors (R.F)	Percent of scores (%)					Mean	Median	St. Deviation	Rank
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely				
		5	4	3	2	1				
OP1	Increase in energy use	**-**	**5.1**	**7.7**	**30.8**	**56.4**	1.62	1.00	.841	*3*
OP2	Higher energy prices	**-**	**-**	**2.6**	**16.7**	**80.8**	1.22	1.00	.474	*1*
OP3	Increasing water costs	**-**	**-**	**3.8**	**21.8**	**74.4**	1.29	1.00	.537	*2*
OP4	Water use restriction	**1.3**	**11.5**	**11.5**	**43.6**	**32.1**	2.06	2.00	1.011	*8*
OP5	Higher costs of repair	**-**	**1.3**	**10.3**	**42.3**	**46.2**	1.67	2.00	.715	*4*
OP6	Increased maintenance regimes	**-**	**3.8**	**10.3**	**44.9**	**41**	1.77	2.00	.788	*6*
OP7	Electricity brownouts and blackouts	**-**	**9**	**15.4**	**59**	**16.7**	2.17	2.00	.813	*9*
OP8	Increased reliance on mechanical cooling	**-**	**5.1**	**20.5**	**38.5**	**35.9**	1.95	2.00	.881	*7*
OP9	More frequent mechanical breakdowns	**1.3**	**6.4**	**34.6**	**42.3**	**15.4**	2.36	2.00	.868	*12*
OP10	Reduced access to infrastructure	**1.3**	**20.5**	**34.6**	**38.5**	**5.1**	2.74	3.00	.889	*16*
OP11	Reduced access to facilities	**2.6**	**24.4**	**346.**	**34.6**	**3.8**	2.87	3.00	.917	*18*
OP12	Increased downtime	**-**	**15.4**	**35.9**	**35.9**	**12.8**	2.54	3.00	.907	*14*
OP13	Increase in the cost of waste water discharge	**-**	**1.3**	**5.1**	**52.6**	**39.7**	1.68	2.00	.637	*5*
OP14	Temporary closure of facilities		**21.8**	**28.2**	**35.9**	**14.1**	2.58	2.50	.987	*15*
OP15	Increased costs due to alternative short-term supplies	**-**	**9**	**25.6**	**47.4**	**17.9**	2.26	2.00	.859	*10*
OP16	Interruption of supply chain	**1.3**	**9**	**25.6**	**50**	**14.1**	2.33	2.00	.878	*11*
OP17	Disruptions of telecommunication services	**1.3**	**11.5**	**30.8**	**43.6**	**12.8**	2.45	2.00	.907	*13*
OP18	Increased slips and falls	**-**	**1.3**	**21.8**	**32.1**	**6.4**	2.79	3.00	.903	*17*

Table 12.3 Descriptive Statistics for Operational Risks Factors

The **OP5 'Higher costs of repair'** operational emerging risk has been chosen as a very likely risk to occur on the building sector according to 46.2% of the respondents. Similarly, approximately 42.3% of the respondents believe that this operational risk is likely to emerge; however, only 15.4% of the respondents to the survey are neutral in relation to this factor.

The average score of the statement is 1.62 (rank = 4) with .715 SD, leading to the important probability influence (median = 2) of this emerging risk on the building sector. The **OP13 'Increase in the cost of waste water discharge'** operational risk also results in an increase in the operational effects on the building sector, where 52.6% of the respondents find that the risk factor is likely to occur, with 39.7% of them recognising that the impact is very likely to arise on buildings and real estate. On the other hand, however, 24.4% of the respondents show neutrality. The average score of this operational risk factor is 1.68 (rank = 5) with .637 SD; hence, the underlying risk factor has a high likelihood (median = 2) of influencing the building sector.

The **OP6 'Increased maintenance regimes'** as operational emerging risk is likely to arise on assets, as shown by 44.9% of the respondents; the impact in terms of this risk factor will be very likely to occur according to 41% of the respondents. The resulting average effect score is 1.77 (rank = 6) with .788 as a standard deviation, hence meaning the highlight operational emerging risk has a potential influence on buildings due to CCS effect.

The risk factor concerned with **OP8 'Increased reliance on mechanical cooling'** shows the operational impact on the building sector according to 38.5% of the respondents, where the impact is more likely (very likely) to happen according to 35.9%. The resulting average score is 1.95 (rank = 7) with .881 SD, meaning that there is a high possibility of influence (median = 2) on buildings and real estate by this risk factor.

It is likely for **OP4 'Water use restriction'** to result in impact on the building sector, as shown by 43% of the respondents, whilst the impact is expected to become higher (very likely) according to 32.1% of them. The percentage of people showing neutrality in this operational risk is 11.5%. The resulting average score is 2.06 (rank = 8) with 1.01 SD, indicating that there is considerable probability to occur (median = 2) on the building sector.

The operational emerging risk which is **OP7 'Electricity brownouts and blackouts'** has been selected as a likely risk to occur by more than half of the respondents (59%), with 16.7% of them believing that it is very likely to emerge, whilst just 15.4% show neutrality. The average likelihood score is 2.17 (rank = 9) with .813 SD, meaning that the impact (median = 2) is likely to happen due to this risk factor.

Based on 47.4% of the respondents, the statement concerned with **OP15 'Increased costs due to alternative short-term supplies'** is likely to have an impact on buildings and real estate, whilst the impact is very likely to occur according to 17.9% of them. On the other hand, approximately one-quarter of the respondents (25.6%) show neutrally towards having any influence. The average effect is 2.00 (rank = 10) with .859 SD, leading to an essential operational risk (median = 2) that could have an impact on buildings. It is likely for OP16 ‘Interruption of supply chain’ to lead to a negative impact on the building sector, as shown by 50% of the respondents, whilst the impact is very likely to arise based on 14.1% of them. It can be noted that approximately one-quarter of the respondents—equating to 25.6%—are neutral. The average impact score is 2.33 (rank = 11) with 1.13 SD. Generally, there are fundamental operational effects (median = 2) from this risk factor on buildings and real estate. The **OP9 ‘More frequent mechanical breakdowns’** operational emerging risk factor is likely to have an impact according to 42.3% of the respondents, whilst the impact is noted as being very likely to occur according to 15.4% of the respondents, whilst almost one-quarter of the respondents (23.1%) shows neutrality. The average impact score is to 2.36 (rank = 12) with .868 SD. Therefore, this operational emerging risk is considered an important emerging risk (median = 2). The operational emerging risk **OP17 ‘Disruptions of telecommunication services’** is likely to have an impact on the building sector, as shown by 34.6% of the respondents; and the impact will be more likely (very likely) to occur according to only 12% of them. The neutrality is observed for 30.8% of the respondents. The resulting average effect score is 1.457 (rank = 13) with .907 SD, hence meaning the underlying risk factor might have clear impacts on buildings and real estate.

On the other hand, the lowest important operational risk factor is **OP11 ‘Reduced access to facilities’** as the average score of its likelihood is 2.87 (rank = 18) with SD of .917. Moreover, the next factors are **OP18 ‘Increased slips and falls’** and **OP10 ‘Reduced access to infrastructure’**, showing an average occurrence likelihood of 2.79 and 2.74 (rank = 17 & 16), respectively, which represent a close mean of .903 and .889 SD, respectively; however, it still indicates a high rate (mean) of the likelihood occurrence of the operational risks on buildings and real estate, compared with the lowest important risk factors in other emerging risks clusters.

12.3.3 Financial Risks Factors

The financial risks emerging from the influences of CCS on the building sector are based on 23 factors, as showed in Table 12.4.

R.F Code	Risks Factors (R.F)	Percent of scores (%)					Mean	Median	St. Deviation	Rank
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely				
		5	4	3	2	1				
F1	Lower profit margins	**1.3**	**16.7**	**30.8**	**41**	**9**	2.60	2.00	.921	*10*
F2	Unable to repay debts	**9**	**33.3**	**32.1**	**23.1**	**2.6**	3.23	3.00	.992	*23*
F3	Equity growth not realised	**3.8**	**20.5**	**50**	**20.5**	**5.1**	2.97	3.00	.882	*19*
F4	Increase in administrative expenses	**1.3**	**10.3**	**25.6**	**48.7**	**14.1**	2.36	2.00	.897	*4*
F5	Reduced ability to secure funding for adaptation due to negative property valuation	**5.1**	**32.1**	**26.9**	**29.5**	**6.4**	3.00	3.00	1.044	*20*
F6	Reduced ability to secure funding for refurbishment due to negative property valuation	**3.8**	**30.8**	**25.6**	**32.1**	**7.7**	2.91	3.00	1.047	*18*
F7	Fall in value of mal-adapted properties	**3.8**	**17.9**	**26.9**	**35.9**	**15.4**	2.59	2.00	1.074	*9*
F8	Loss of income from properties	**1.3**	**24.4**	**30.8**	**28.2**	**15.4**	2.68	3.00	1.051	*13*
F9	Businesses become less competitive	**5.1**	**33.3**	**25.6**	**33.3**	**2.6**	3.05	3.00	.992	*21*
F10	Properties may not be saleable because of climate change compliance	**2.6**	**24.4**	**24.4**	**32.1**	**16.7**	2.64	3.00	1.105	*12*
F11	Negative property valuation due to structural damage	**6.4**	**25.6**	**26.9**	**30.8**	**10.3**	2.87	3.00	1.109	*16*
F12	Negative property valuation due to services damage or compliance with climate change legislation	**5.1**	**21.8**	**26.9**	**37.2**	**9.0**	2.77	3.00	1.056	*14*
F13	Loss of revenue due to customer behaviour	**3.8**	**20.5**	**39.7**	**32.1**	**3.8**	2.88	3.00	.911	*17*
F14	Changing patterns of consumer demand	**2.6**	**7.7**	**26.9**	**48.7**	**14.1**	2.36	2.00	.911	*5*
F15	Affordability of property rent/development	**2.6**	**10.3**	**30.8**	**43.6**	**12.8**	2.46	2.00	.935	*6*
F16	Increase costs to purchase	**1.3**	**9**	**11.5**	**47.4**	**30.8**	2.03	2.00	.953	*3*
F17	Increased insurance excess	**1.3**	**1.3**	**9**	**52.6**	**35.9**	1.79	2.00	.762	*1*
F18	Additional expense in insuring buildings prone to the urban heat island effect	**3.8**	**17.9**	**20.5**	**41**	**16.7**	2.51	2.00	1.090	*7*
F19	Additional expense in insuring buildings in flood risk zones	**3.8**	**6.4**	**11.5**	**38.5**	**39.7**	1.96	2.00	1.062	*2*
F20	Increases in areas prone to soil heave/shrinkage	**3.8**	**12.8**	**30.8**	**42.3**	**10.3**	2.58	2.00	.974	*8*
F21	Un-insurability due to climate change	**10.3**	**32.1**	**26.9**	**20.5**	**10.3**	3.12	3.00	1.162	*22*
F22	Affordability of property insurance	**5.1**	**16.7**	**26.9**	**37.2**	**14.1**	2.62	2.00	1.084	*11*
F23	Availability of property insurance	**7.7**	**23.1**	**26.9**	**29.5**	**12.8**	2.83	3.00	1.156	*15*

Table 12.4 Descriptive Statistics for Financial Emerging Risk Factors

The **F17 'Increased insurance excess'** as financial risk is the most likely risk factor to arise across buildings and real estate due to threats of CCP according to 52.6% of the respondents, with the impact becoming very likely to occur according to 35.9% of them. This results in an average impact equal to 1.79 (rank = 1) with .762 standard deviation; therefore, this financial risk factor is considered a very important effective factor (median = 1).

Based on 39.7% of the respondents, the statement concerned with **F19 'Additional expense in insuring buildings in flood risk zones'** is very likely to have impacts on the building sector; the impact is likely to occur according to 38.5% of them. The average likelihood occurrence is 1.96 (rank = 2), with 1.96 SD, leading to an essential effect (median = 2) by this risk factor. It is likely for **F16 'Increase costs to purchase'** to lead to a negative impact on buildings and real estate, as shown by 47.4% of the respondents, with the impact noted as being very likely to emerge for 30.8% of them. The average impact score is 2.03 (rank = 3) with 1.13 SD. Generally, there are fundamental effects from this financial risk factor (median = 2) on the building sector. The influence of **F4 'Increase in administrative expenses'** on the building sector is very likely to occur according to almost half of the respondents, where 48.7% and then 14.1% of them believe that such risk are very likely to appear, whilst 25.6% of them show neutrality. The average score of likelihood for this financial risk is 2.36 (rank = 4) with .897 SD, meaning the impact (median = 2) is likely to happen due to this risk factor. The **F14 'Changing patterns of consumer demand'** is expected to increase the financial effects on the building sector, according to approximately half of the respondents (48.7%) and the effect is highly expected (very likely) to occur, as shown by 14.1% of them; however, only, 26.9% of the respondents were found to be neutral. The average impact effect of this statement is 2.36 (rank = 5) with .911 SD, leading to a fundamental influence (median = 2) on buildings and real estate. The **F15 'Affordability of property rent/development'** also results in increased financial impacts, where 43.6% of the respondents find the effect due to this risk factor being likely to arise, whilst 12.8% of them think it is very likely to occur. On the other hand, however, 30.8% of the respondents show neutrality. The average probability effect score is 2.46 (rank = 6) with .935 SD, hence meaning this factor has a potential essential effect (median = 2) on the building sector. The statement concerned with **F18 'Additional expense in insuring buildings prone to the urban heat island effect'** is found to have an impact on the building sector, according to approximately 41% of the respondents, whilst 16.7% of them consider the impact to be very likely to emerge. The neutrality is observed for 20.5% of the respondents. The average possibility of its likelihood occurrence is

2.51 (rank = 7) with 1.09 SD; hence, it is deduced that there is real financial impact (median = 2) on the buildings and real estate due to this financial emerging risk. It is likely for **F20 'Increases in areas prone to soil heave/shrinkage'** to have an impact on the building sector, as shown by 42.3% of respondents, whilst the impact becomes more likely to occur (very likely) according to 10.3% of them. The percentage of people showing neutrality is 30.8%, whilst 12.1% of the respondents think that it is unlikely to induce an impact in terms of this financial emerging risk. According to resulting mean, which is 2.58 (rank = 8) with .974 SD, there is financial impact (median = 2) likely to occur on buildings and real estate due to this risk factor. According to 35.9% of the respondents, **F7 'Fall in value of mal-adapted properties'** is likely to have an effect on building assets, whilst only 15.4% of them consider that the effect due to the his financial risk factor is very likely to emerge on property. Moreover, approximately one-quarter of the respondents—equating to 26.9%—show neutrality in terms of this emerging risk factor. The average score of possibility effect is 2.59 (rank = 9) with 1.7 SD, which means that the underlying statement has an important effect on the building sector in a financial way. The **F1 'Lower profit margins'** as emerging financial risk is likely to have an impact on the building sector according to 41% of the respondents, whilst only the impact is noted to be very likely according to 9% of them, whereas more than one-quarter of the respondents, equating to 30.8%, show neutrality. The average score of the likelihood of occurrence is 2.60 (rank = 10), with .921 standard deviation, meaning the effect of this risk factor is considered an important (median = 2) potential risk factor. More than one-quarter of the respondents believe that the financial risk factor that is **F22 'Affordability of property insurance'** will likely impact on the building sector, as shown by 37.2% of them; and the impact will be more likely (very likely) to occur according to 14.1% of the respondents. The neutrality is observed for 26.9%. The resulting average score of its probability emergence is 2.62 (rank = 11) with 1.084 SD, hence meaning the underlying risk factor is considered a financial risk factor.

The neutrality is observed for the remaining financial risks factors from the influences of CCS, as presented in Table 12.4. Moreover, the lowest likelihood occurrence financial risk is **F2 'Unable to repay debts'** as around 65.4% of the respondents it is unlikely and are neutral with a resulting mean of 3.23 (rank = 23) and .992 SD. The next two less important financial risk factors are **F21 'Un-insurability due to climate change'** and **F9 'Business become less competitive'**, with 3.12 and 3.23 as the average possibility of likelihood occurrence (rank = 22 & 21) in SD of 1.162 and .991, respectively.

12.3.4 Occupant Dissatisfaction Risks Factors

The emerging risks factors arising from occupant dissatisfaction consist of 6 statements, where the survey result in terms of these emerging risk factors is given in Table 12.5.

The **O1 'Thermal discomfort'** as a risk factor related to occupant satisfaction is considered to be the most important emerging risk according to 41% of the respondents, whilst 37.3% of them recognise that the impact is very likely to occur due to the influences of climatic patterns. The neutrality is observed for 15.4% of the respondents. The average likelihood occurrence of its impacts is 1.94 (rank = 71) with .958 SD; hence, it is deduced that this risk factor has a very essential potential impact (median = 1) on the building sector. It is likely for the **O2 'Loss of productivity'** to result in an impact on the building sector, as shown by 43.6% of the respondents, whilst the impact becomes more likely to occur according to 21.8% of them. The percentage of people showing neutrality is 19.2%. According to the resulting average score, the possibility impact of this factor is 2.32 (rank = 2) with 1.06 SD, thus indicating that this risk factor is assigned first place in terms of its essential emergence impact (median = 2) on the buildings and real estate.

R.F Code	Risks Factors (R.F)	Percent of scores (%)					Mean	Median	St. Deviation	Rank
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely				
		5	4	3	2	1				
O1	Thermal discomfort	**2.6**	**3.8**	**15.4**	**41**	**37.2**	1.94	2.00	.958	*1*
O2	Loss of productivity	**3.8**	**11.5**	**19.2**	**43.6**	**21.8**	2.32	2.00	1.063	*2*
O3	Heat related health risks	**3.8**	**9.0**	**32.1**	**32.1**	**23.1**	2.38	2.00	1.060	*3*
O4	Usability of Buildings become impaired	**3.8**	**16.7**	**20.5**	**44.9**	**14.1**	2.51	2.00	1.054	*4*
O5	Business continuity impaired	**7.7**	**20.5**	**21.8**	**35.9**	**14.1**	2.72	2.50	1.172	*5*
O6	Occupant litigation	**9.0**	**11.5**	**35.9**	**33.3**	**10.3**	2.76	3.00	1.083	*6*

Table 12.5 Descriptive Statistics for Occupant Dissatisfaction Risks Factor

According to 32.1% of the respondents, the **O3 'Heat-related health risks'** is likely to emerge on buildings' occupants, whilst according to 23.1% of them, the effect due to this risk factor is very likely to happen. More than one-quarter of the respondents, equating to 32.1%, show neutrality in terms of the impact from this risk factor. The average effect score is 2.38 (rank = 3) with 1.06 SD, meaning that the risk factor plays a pivotal role (median = 3) in affecting occupant satisfaction in the building sector.

The **O4 'Usability of Buildings become impaired'** results in effects to satisfaction of the buildings' occupants, as shown by 44.9% of the respondents; the impact will be more likely to arise according to 14.1% of the respondents. Neutrality is observed for 20.5% of the respondents. The average score of its probability to emerge is 2.51 (rank = 4) with 1.05 SD, hence meaning this risk factor is likely (median = 2) to occur in the building sector. The risk factor concerned with **O5 'Business continuity impaired'** is found to have an impact on the building sector, according to 35.9% of the respondents, whilst 14.1% of them consider that the impact is very likely to occur. The neutrality is observed for 21.8% of the respondents. The average likelihood impact score is 2.72 (rank = 5) with 1.172 SD, hence meaning it can be deduced that this statement has an essential impact (median = 2.50) on buildings and real estate in terms of occupant satisfaction.

12.3.5 Liability and Responsibility Risks Factors

The influence of **LR4 'Increasing environmental litigation'** on the buildings sector is likely to occur according to 47.4% of the respondents, with 11.5% of them believing that it is very likely to arise, whilst 28.2% of them show neutrality. The average likelihood occurrence score of this risk factor is 2.47 (rank = 1) with .977 SD, which means that the impact (median = 1) is very likely to happen due to this risk factor.

R.F Code	Risks Factors (R.F)	Percent of scores (%)					Mean	Median	St. Deviation	Rank
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely				
		5	4	3	2	1				
LR1	Increase of recourse action against professional advisors	**10.3**	**11.5**	**33.3**	**35.9**	**9**	2.78	3.00	1.101	*4*
LR2	Buildings dangerous to health as a result of high temperature	**7.7**	**16.7**	**33.3**	**35.9**	**6.4**	2.83	3.00	1.037	*5*
LR3	Increase of claims in contract or tort because buildings designed, or operated in a way that has insufficient regard to the reasonably anticipated impacts of climate change	**12.8**	**11.5**	**38.5**	**32.1**	**5.1**	2.95	3.00	1.080	*6*
LR4	Increasing environmental litigation	**5.1**	**7.7**	**28.2**	**47.4**	**11.5**	2.47	2.00	.977	*1*
LR5	Increasing decommissioning liabilities	**6.4**	**10.3**	**30.8**	**41**	**11.5**	2.59	2.00	1.037	*2*
LR6	Professionals (advisers, designers, owners, tenant, insurers) will bear the responsibility of mal-adapted new buildings	**5.1**	**19.2**	**26.9**	**41**	**7.7**	2.73	3.00	1.028	*3*

Table 12.6 Descriptive Statistics for Liability and Responsibility Risks Factors

The **LR5 'Increasing decommissioning liabilities'** is expected (likely) to increase the effect on the building sector, according to 41% of the respondents, whilst the effect is highly expected (very likely) to appear as shown by 11.1% of them. However, only 30.8% of them are neutral. The average score of likelihood emergence of this statement is 2.59 (rank = 2) with 1.04 SD, leading to fundamental influence (median = 2) on buildings and real estate.

According to 41% of the respondents, **LR6 'Professionals (advisers, designers, owners, tenant, insurers) will bear the responsibility of maladapted new buildings'** is likely to happen as liability and responsibility risk factor due to the influences of CCS. Notably, only 7.7% of the respondents believe that this risk factor is very likely to arise against professionals in the building sector. On the other hand, however, more than one-quarter of the respondents (26.9%) show neutrality. The average score of the possibility of this risk factor occurring is 2.73 (rank = 3) with 1.028 SD; hence, this statement has quite an important effect (median = 2) on the building sector in terms of liability and responsibility emerging risks.

For the rest of the risk factors related to the liability and responsibility within buildings and real estate, the resulting mean and median shows neutrality as illustrated in Table 12.6 above.

12.3.6 Reputational Risks Factors

The emerging reputational risks related to the threat of CCS on the building sector are based on 15 risks factor, as illustrated in Table 12.7 below.

Built on the analysis results, the **R13 'Increased carbon emissions'** is likely to have an impact on buildings and real estate, according to 41% of the respondents, whilst it is very likely to occur according to 32.1% of respondents. Using the average effect score, which is 2.06 (rank = 1) with .998 SD, this reputational risk generally has the most important factor in terms of its likelihood of occurrence (median = 1.00) on the building sector from a reputational perspective.

The same result can be seen for the statement concerned with **R9 'Higher liabilities risks'**. More specifically, this risk factor is likely to have impacts according to 56.4% of the respondents, whilst it is very likely to emerge according to 10.3% of the respondents. The average effect score is 2.28 (rank = 2) with SD=.737, and hence, there is an important impact potentially appearing from this emerging risk (median = 2) on buildings and real estate. Similarly, around half of the respondents (43.6%) believe that the **R14 'Increased level of staff stress'** risk factor is likely to emerge on the building sector, whilst this impact is very likely to occur according to 17.9% of them. As a result, the average effect score is found to be 2.35 (rank = 3) with .951 SD, meaning that there is essential effect (median = 2) on buildings and real estate.

The factor concerned with **R7 'Higher economic risks'** shows an impact on the building sector; according to 42.3% of the respondents, the impact becomes higher (very likely) according to 16.7% of them. The average score of its possibility of emergence is 2.40 (rank = 4) with .985 SD, thus meaning there is generally an influence (median = 2.00) on the building sector.

It is likely for the **R12 'Increased sick days'** to occur as an impact on the building sector, as shown by 35.9% of the respondents, whilst this risk factor is more likely to arise (very likely) according to 19.2% of the respondents. The percentage of people showing neutrality is 32.1%. The average score of likelihood effect of this risk factor is 2.41 (rank = 5) with .999 SD, indicating that considerable impact might occur (median = 2) on the building sector.

The **R8 'Higher legal risks'** can play a crucial role in increasing the impact on the building sector in terms of reputational risk, where 50% of the respondents believe that this risk is likely to occur, and 10.3% of them believe that it is very likely to appear. Moreover, about 30.8% of the respondents showed neutrality. The average likelihood of it to occur is 2.42 (rank = 6) with .890 SD, meaning that the reputational impact is likely (median = 2) to occur due to this factor.

It is likely for the **R4 'Loss of organisations' sustainability credential'** to result in an impact on the building sector, as shown by 48.7% of the respondents, whilst the impact to become more likely to emerge (very likely) is stated by 12.8% of them. The percentage of people showing neutrality in this risk factor is 21.8% of the respondents. According to the resulting average score, which is 2.47 (rank = 7) with 1.03 SD, reputational impact might occur (median = 2) on the buildings and real estate due to this risk factor.

According to 42.3% of the respondents, the **R2 'Negative impact on corporate social responsibility'** is likely to have an effect, whilst, according to 12.8%, the effect due to this factor is very likely to emerge. Moreover, more than one-quarter of the respondents, equating to 39.5%, shows neutrality in terms of the impact of this risk factor. The average score of the likelihood occurrence of this reputational risk is 2.50 (rank = 8) with .964 SD, meaning that the underlying risk factor has a quite important reputational effect (median = 2) on buildings and real estate.

According to 41% of the respondents, the **R3 'Market differentiation'** as reputational risk is likely to have an impact on the building sector; this will be more likely (very likely) to appear according to 11.5% of the respondents. The neutrality is observed for 35.9% of the respondents. The resulting average effect score is 2.50 (rank = 9) with .908 SD; hence, this reputational risk has an impact that might be seen to emerge (median = 2) on buildings and real estate.

R.F Code	Risks Factors (R.F)	Percent of scores (%)					Mean	Median	St. Deviation	Rank
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely				
		5	4	3	2	1				
R1	Loss of economic benefits	**2.6**	**16.7**	**28.2**	**37.2**	**15.4**	2.54	2.00	1.028	*11*
R2	Negative impact on corporate social responsibility	**2.6**	**12.8**	**29.5**	**42.3**	**12.8**	2.50	2.00	.964	*8*
R3	Market differentiation	**2.6**	**9**	**35.9**	**41**	**11.5**	2.50	2.00	.908	*9*
R4	Loss of organisations' sustainability credential	**5.1**	**11.5**	**21.8**	**48.7**	**12.8**	2.47	2.00	1.028	*7*
R5	Loss of investors	**7.7**	**16.7**	**37.2**	**34.6**	**3.8**	2.90	3.00	.988	*15*
R6	Lower staff retention and productivity due to building usability	**7.7**	**21.8**	**30.8**	**30.8**	**9**	2.88	3.00	1.093	*14*
R7	Higher economic risks	**3.8**	**7.7**	**29.5**	**42.3**	**16.7**	2.40	2.00	.985	*4*
R8	Higher legal risks	**3.8**	**5.1**	**30.8**	**50**	**10.3**	2.42	2.00	.890	*6*
R9	Higher liabilities risks	**1.3**	**2.6**	**29.5**	**56.4**	**10.3**	2.28	2.00	.737	*2*
R10	Loss of potential customers due to business interruption	**2.6**	**24.4**	**30.8**	**32.1**	**10.3**	2.77	3.00	1.018	*13*
R11	Negative impact on organisations' brand and reputation	**3.8**	**15.4**	**37.2**	**33.3**	**10.3**	2.69	3.00	.984	*12*
R12	Increased sick days	**2.6**	**10.3**	**32.1**	**35.9**	**19.2**	2.41	2.00	.999	*5*
R13	Increased carbon emissions	**2.6**	**6.4**	**17.9**	**41**	**32.1**	2.06	2.00	.998	*1*
R14	Increased level of staff stress	**1.3**	**11.5**	**25.6**	**43.6**	**17.9**	2.35	2.00	.951	*3*
R15	Negative impact on organisations reputation from being seen as a contributor to climate change	**3.8**	**10.3**	**28.2**	**48.7**	**9**	2.51	2.00	.936	*10*

Table 12.7 Descriptive Statistics for Reputational Risks Factors

The risk factor concerned with **R15 'Negative impact on organisations reputation from being seen as a contributor to climate change'** is found to have an impact on the building sector according to almost half of the respondents (48.7%), whilst just 9% of them recognise that the impact is very likely to occur. The neutrality is observed for 28.2% of them. The average score of the probability impact of this risk factor is 2.51 (rank = 10) with .936 SD; hence, it is deduced that this factor has an essential reputational impact expected to occur (median = 2) on the building sector.

The **R1 'Loss of economic benefits'** is recognised as a reputational risk likely to threaten the building sector according to 37.2% of the respondents, whilst 15.8% of them believe it is very likely to arise. On the other hand, however, approximately 28.2% of the respondents show neutrality. The average score of the likelihood of occurrence of its impact of this risk factor is 2.54 (rank = 11), with a 1.03 standard deviation (SD); hence, this risk factor has an effect that might be likely to occur (median = 2) on buildings and real state.

On the other hand, however, the lowest likelihood reputational risk that might occur on buildings is **R5 'Loss of investors'**, with more than half of the respondents (61.6%) holding the view that this risk factor is very unlikely or unlikely to occur on buildings and real estate, whilst the majority of them (37.2%) observed this to neutral. The average score of likelihood occurrence of this risk factor is 2.90 (rank = 15), with .988 SD. The subsequent risk factors observed as less important are **R6 'Lower staff retention and productivity due to building usability'** and R10 **'Loss of potential customers due to business interruption'**, with an average score of their likelihood emergence of 2.88 and 2.77 (rank = 14 & 13) in SD of 1.093 and 1.018, respectively.

12.3.7 Regulatory Risks Factors

The factors of regulation-related emerging risks comprise 7 statements relating to the risks of CCP. The statistical survey results are given in Table 12.8 below.

The factor concerned with the **RE7 'Uncertainty of pending legislation on climate change'** is found to potentially impact the building sector according to 47.4% of the respondents, whilst 37.2% of them think that the impact is very likely to occur. The neutrality is observed for 12.8% of them. The average likelihood of its impact is 1.82 (rank = 1) with .802 SD, meaning it has been deduced that this risk factor has a pivotal impact that might appear (median = 2) on the buildings and real estate from a regulation perspective.

It is likely for the **RE5 'Strict limits on greenhouse gas emissions'** that an impact will result on the building sector, as shown by almost half of the respondents (48.7%), and then the impact is more likely to become higher (very likely) to arise, according to 30.8% of them. According to resulting average score, which is 1.96 (rank = 2) with .844 SD, there is an impact from this emerging risk, which might emerge (median = 2) on the building sector from this regulation factor.

According to more than half of the respondents (66.7%), which is a high percentage, the **RE6 'Mandatory climate change risk-appropriate building regulation'** is likely to emerge whilst, according to 19.2% of them, the effect due to this factor is very likely to arise. The average score of the likelihood of occurrence of this risk factor is 2.01 (rank = 3) with .764 SD, which means that the underlying factor has quite a important effect that might occur (median = 2) on the building sector.

The **RE1 'Stringent regulation in relation to water stress'** is noted as being likely to have an impact on the building sector, as shown by 47.4% of the respondents; the impact will be very likely to appear according to 17.9% of them. The neutrality is observed amongst 24.4% of the respondents. The resulting average score of its likelihood impact occurrence is 2.27 (rank = 4) with .878 SD, and hence this regulation risk has likely emergence (median = 2) on buildings and real estate.

R.F Code	Risks Factors (R.F)	Percent of scores (%)					Mean	Median	St. Deviation	Rank
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely				
		5	4	3	2	1				
RE1	Stringent regulation in relation to water stress	**-**	**10.3**	**24.4**	**47.4**	**17.9**	2.27	2.00	.878	*4*
RE2	Stringent regulation in relation to flood stress	**2.6**	**11.5**	**16.7**	**50**	**19.2**	2.28	2.00	.992	*5*
RE3	Stringent regulation in relation to overheating stress	**2.6**	**14.1**	**25.6**	**44.9**	**12.8**	2.49	2.00	.977	*6*
RE4	Stringent regulation in relation to windstorms stress	**6.4**	**21.8**	**28.2**	**38.5**	**5.1**	2.86	3.00	1.028	*7*
RE5	Strict limits on greenhouse gas emissions	**-**	**6.4**	**14.1**	**48.7**	**30.8**	1.96	2.00	.844	*2*
RE6	mandatory climate change risk-appropriate building regulation	**2.6**	**1.3**	**10.3**	**66.7**	**19.2**	2.01	2.00	.764	*3*
RE7	Uncertainty of pending legislation on climate change	**1.3**	**1.3**	**12.8**	**47.4**	**37.2**	1.82	2.00	.802	*1*

Table 12.8 Descriptive Statistics for regulatory Risks

The risk factor concerned with **RE2 'Stringent regulation in relation to flood stress'** shows that exactly half of the respondents (50%) believe that this factor will occur on the building sector, with 19.2% of them believing that this impact is very likely to arise. The neutrality is observed amongst 16.7% of the sample. The average probability emergence impact is 2.28 (rank = 5) with .958 SD; hence, it is deduced that this factor has an essential regulation impact that is likely to happen (median = 2) on buildings and real state.

The regulation risk factor **RE3 'Stringent regulation in relation to overheating stress'** is likely to appear on buildings and real estate according to 44.9% of the respondents, whilst 12.8% of them think it is very likely to occur. On the other hand, however, 25.6% of the respondents show neutrality. The average effect likelihood occurrence score of this emerging risk factor is 2.49 (rank = 6) with .977 SD; hence, its effect is likely to emerge (median =2) under regulation perspective.

12.3.8 Climate Change Risk Management Factors

The factors of climate change risk management are based on 24 strategy factors, as presented in Table 12.9. These CCRM factors are measured by the extent of their effectiveness level on the building sector in terms of mitigating the climate change risks. Moreover, the respondents were asked whether their employing organisations, sectors and institutions adopted these strategies. The findings are presented in Figure 12-9 below. The following descriptive illustrates the most important strategies of CCRM factors.

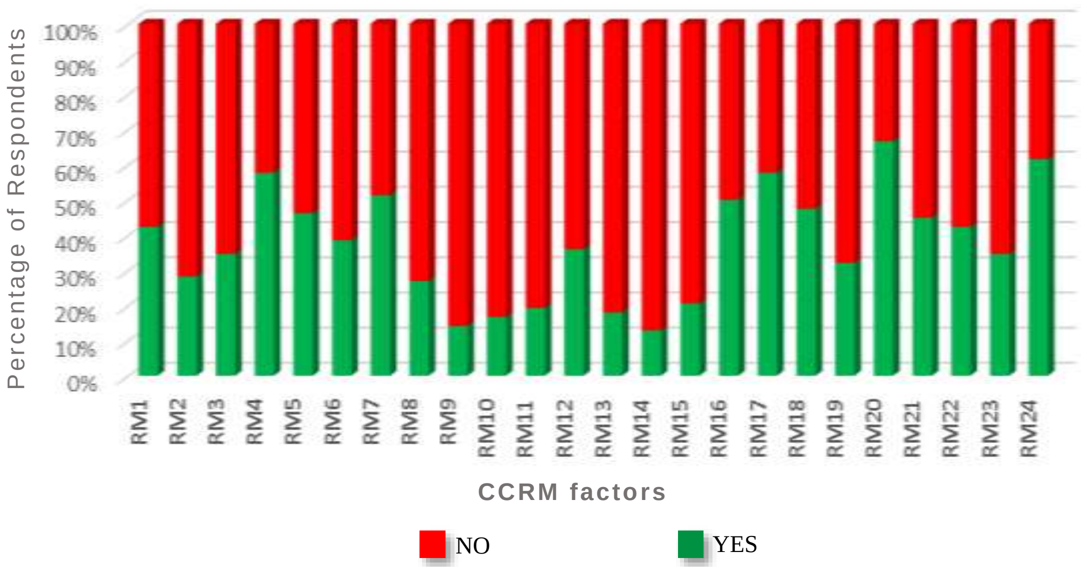

Figure 12-9 Percentages of the CCRM Factors Used by Respondents' Organisations

According to almost half of the respondents (47.4%), the **RM20 'Strategy to improve energy efficiency'** is the most effective strategy in climate change mitigation, and around 43.6% of them consider it as an effective strategy. Built on this, the average effective score is equal to 1.65 (rank = 1) with a standard deviation of .752; therefore, this statement is important (median = 2) in coping with the risks of climate change. In addition, this strategy plays an essential role in climate change mitigation as it is used by 42.3% of the respondents' organisations. Based on 42.3% of the respondents, the statement concerned with **RM17 'Plans to improve equipment to reduce emissions'** plays a pivotal role in controlling the CCR; a very similar percentage show that the effect becomes higher (very effective) according to 43.6%. The average effective score of this strategy is 1.75 (rank = 2) with .824 SD, leading to being an essential effective (median = 2) tool in managing emerging CCR. This is adopted by 57.7% of organisations in the building sector.

The **RM4 'Maintenance planning'** strategy is expected to be effective on mitigation and adaptation buildings and real estate, according to 47.4% of the respondents, and the effect is highly expected (very effective), as shown by 32.1% of them. However, 19.2% of the respondents are neutral. The average effective score of this statement is 1.90 (rank = 3) with .749 SD, leading to fundamental effectiveness (median = 2) in controlling and managing CCR in the building sector. According to 57.7% of the respondents, their organisations used this strategy.

The climate change risk management factor, which is **RM7 'Maintenance scheduling'**, also resulted in an increased effective mitigation process when compared against the emerging risks from CCS on the building sector, as supported by 44.9% of the respondents, with 33.3% of them recognising that his might be very effective. On the other hand, however, 19.2% of the respondents show neutrality. The average effective level score is 1.91 (rank = 4) with .793 SD; hence, the strategy plays a significant role (median = 2) in mitigating and adapting buildings and real estate with emerging risks, as it is adopted by approximately half of the organisations (51.3%) in the building sector.

The factor concerned with the **RM21 'Increasing use of renewable energy'** is noted as being an effective strategy according to 52.6% (approximately half of the respondents), whilst 32.1% of them recognise that it will be a very effective factor. The average score of its effectiveness level is 1.91 (rank = 5) with .855 SD, thus meaning it can be deduced that this strategy might be an effective tool (median = 2) from a mitigation and adaptation perspective in relation to CCP threatening the building sector. Moreover, this strategy is applied by 44.9% of the organisations and sectors in the building sector.

It is likely for the **RM16 'FM strategies to improve properties to reduce emissions'** to be effective risk management tools in the building sector, as shown by 48.7% of the respondents, whilst the effect becomes greater (very effective) according to 30.8% of them. The percentage of people showing neutrality is 15.4% of the respondents. According to resulting mean, which is 1.96 (rank = 6) with .860 SD, this risk management strategy plays a pivotal role (median = 2) in terms of the control of the emerging risks in the building sector. Moreover, it is adopted by exactly half of the organisations (50%), as respondents showed.

The **RM5 'Operations planning'** is expected to be effective in buildings and real estate mitigation, according to 53.8% of the respondents; however, the effectiveness is highly expected (very effective), as shown by around one-quarter (24.4%) of them. However, only, 21.8% of them show neutrality in this strategy. The average score of the effectiveness level of this statement is 2.00 (rank = 7) with .683 SD, leading to being an effective plan (median =2) on the building sector, as applied by 46.2% of organisations.

S.F Code	Strategy Factors (S.F)	Percent of scores (%)					Mean	Median	St. Deviation	Rank
		Very Ineffective	Ineffective	Neutral	Effective	Very Effective				
		5	4	3	2	1				
RM1	Disruption planning	**-**	**1.3**	**30.8**	**56.4**	**11.5**	2.22	2.00	.658	*19*
RM2	Balancing resources	**3.8**	**23.1**	**35.9**	**50**	**10.3**	2.33	2.00	.715	*21*
RM3	Stand-by-preparation	**-**	**1.3**	**32.1**	**52.6**	**14.1**	2.21	2.00	.691	*17*
RM4	Maintenance planning	**-**	**1.3**	**19.2**	**47.4**	**32.1**	1.90	2.00	.749	*3*
RM5	Operations planning	**-**	**21.8**	**21.8**	**53.8**	**24.4**	1.97	2.00	.683	*7*
RM6	Resource planning	**-**	**2.6**	**23.1**	**56.4**	**17.9**	2.10	2.00	.713	*14*
RM7	Maintenance scheduling	**-**	**2.6**	**19.2**	**44.9**	**33.3**	1.91	2.00	.793	*4*
RM8	Adaptation planning	**6.4**	**23.1**	**50**	**19.2**	**1.3**	2.14	2.00	.849	*15*
RM9	Property portfolio climate change risk management	**-**	**2.6**	**38.5**	**35.9**	**23.1**	2.21	2.00	.827	*18*
RM10	Financial stress emergency plans	**-**	**12.8**	**35.9**	**38.5**	**12.8**	2.49	2.00	.879	*24*
RM11	Development of new compliance infrastructure	**-**	**2.6**	**35.9**	**46.2**	**15.4**	2.26	2.00	.746	*20*
RM12	Mitigation plans for disruption to business processes	**-**	**5.1**	**23.1**	**42.3**	**29.5**	2.04	2.00	.860	*10*
RM13	Plans to deal with changes in market demand	**-**	**5.1**	**38.5**	**38.5**	**16.7**	2.36	2.00	.868	*22*
RM14	Mitigation plans for disruption to supply chain	**1.3**	**5.1**	**37.2**	**42.3**	**14.1**	2.37	2.00	.839	*23*
RM15	Availability of resources	**1.3**	**1.3**	**30.8**	**48.7**	**17.9**	2.19	2.00	.790	*16*
RM16	FM strategies to improve properties to reduce emissions	**1.3**	**3.8**	**15.4**	**48.7**	**30.8**	1.96	2.00	.860	*6*
RM17	Plans to improve equipment to reduce emissions	**-**	**5.1**	**9**	**42.3**	**43.6**	1.75	2.000	.824	*2*
RM18	Plans to manage water footprint	**-**	**5.1**	**14.1**	**55.1**	**25.6**	1.98	2.00	.781	*9*
RM19	Plans to use adaptation technology	**-**	**3.8**	**20.5**	**52.6**	**23.1**	2.05	2.00	.771	*11*
RM20	Strategy to improve energy efficiency	**-**	**3.8**	**5.1**	**43.6**	**47.4**	1.65	2.00	.752	*1*
RM21	Increasing use of renewable energy	**1.3**	**5.1**	**9.0**	**52.6**	**32.1**	1.91	2.00	.855	*5*
RM22	Plans to generate renewable energy on site	**1.3**	**6.4**	**20.5**	**41**	**30.8**	2.06	2.00	.944	*12*
RM23	Water management mitigation plans	**-**	**6.4**	**14.1**	**55.1**	**24.4**	2.06	2.00	.805	*13*
RM24	Waste management plans	**-**	**9**	**12.8**	**46.2**	**32.1**	1.97	2.00	.904	*8*

Table 12.9 Descriptive Statistics for Climate Change Risk Management

It is likely for **RM24 'Waste management plans'** to be an effective tool in mitigating and adapting assets, as shown by 46.2% of the respondents, whilst its effectiveness level becomes greater (very effective) according to 32.1% of them. The percentage of people showing neutrality amounted to 12.8% of the respondents. According to the average score of the effective level, which is 1.97 (rank = 8) with .904 SD, this CCRM strategy might be an effective tool (median = 2) in mitigating and adapting buildings and real estate to the emerging CCR. In addition, it is adopted by more than half (62%) of the respondents' organisations.

According to 55.1% of the respondents—which is a high percentage—the **RM18 'Plans to manage water footprint'** strategy plays pivotal role in mitigate the building sector to climate change. According to 25.6% of them, the effectiveness of this tool is very high (very effective). The average effective score is 1.98 (rank = 9) with .781 SD. This means that the underlying statement is an important effective strategy (median =2) as it is applied by almost half of the organisations and institutions (47.4%) in the building sector.

The climate change risk management strategy which is **RM12 'Mitigation plans for disruption to business processes'** might be an effective factor, as shown by 42.3% of the respondents. The effectiveness level is expected to increase (very effective) according to 29.5% of the subjects. The neutrality is observed for 23.1% of the respondents. The resulting average effective score is 2.04 (rank = 10) with .860 SD; as a result of this, the highlighted CCRM strategy plays an important role in the mitigation and adaptation perspective (median = 2), and is implemented by 36% of the organisations in the building sector.

The strategy is concerned with the **RM19 'Plans to use adaptation technology'**, which shows a significant effect according to more than half of the respondents (52.6%), and then 23.1% of them think that it could be very effective in mitigating and adapting buildings and real estate. The neutrality is observed for 20.5% of them. The average score of effectiveness level is 2.05 (rank = 11) with .944 SD; this factor has an essential effective (median = 2) in dealing with emerging risks from CCS as it is used by 32% of the organisation and institutions in the building sector.

The **RM22 'Plans to generate renewable energy on site'** is expected to be effective on the building sector according to 41% of the respondents, whilst 30.8% of them think it might be a very effective factor. On the other hand, however, 20.5% of them show neutrality. The average score of its effectiveness level is 2.06 (rank = 12) with .944 SD; as a result of this, it is considered an effective (median =2) CCRM tool. Moreover, it is applied by approximately 42.3% of the organisations in the building sector.

According to more than half of the respondents (55.1%) believe that the **RM23 'Water management mitigation plans'** is an effective strategy in terms of mitigating buildings and real estate to the CCR, where the effectiveness is higher (very effective) according to 24.4% of them. The neutrality is observed for 14.1% of the respondents. The resulting average effective score is 2.06 (rank = 13) with .805 SD; hence, the underlying statement has an effective (median = 2) role in the building sector from a mitigation and adaptation perspective. Additionally, this CCRM strategy is adopted by around 34.6% of organisations and institutions.

The statement concerned with the **RM6 'Resource planning'** shows a major effect in the building sector, according to 56.4% of the respondents, whilst 17.9% of them consider that the effectiveness level is very expected. The neutrality is noted for around 23.1% of the respondents. The average effectiveness level score is 2.10 (rank = 14) with .713 SD, thus indicating that this strategy factor has an essential effective role (median = 2) in mitigating and adapting buildings and real estate. Furthermore, it is used by approximately 38.5% of the organisations.

For the remainder of the climate change risk management strategies, it can be recognised that the higher percentage of respondents are located between effective and neutrality, as illustrated in Table 12.9 above.

On the other hand, the lowest effective CCRM factor is **RM10 'Financial stress emergency plans'**, with an average score of effectiveness level of 2.49 (rank = 24) with .879 as SD. The next two lowest important CCRM factors are **RM14 'Mitigation plans for disruption to supply chain'** and **RM13 'Plans to deal with changes in market demand'**, with an average score of their effectiveness level of 2.37 and 2.36 (rank = 23 & 22). These can be observed as very closely rated, with .839 and .868 as SD, respectively. However, these factors are no less important than other factors; nonetheless, they were positioned last in the ranking list in terms of their effectiveness level based on the opinions of the study respondents.

12.4 Descriptive Analysis of Timeframe for Emerging Risk Factors

This section in this chapter considers the results of the timeframe occurrence for the top 5 emerging risk factors in each emerging risk cluster from both view types, i.e. organisation and the type of professional role.

12.4.1 Physical Risk Factors

12.4.1.1 Timeframe Based on the Type of Organisation

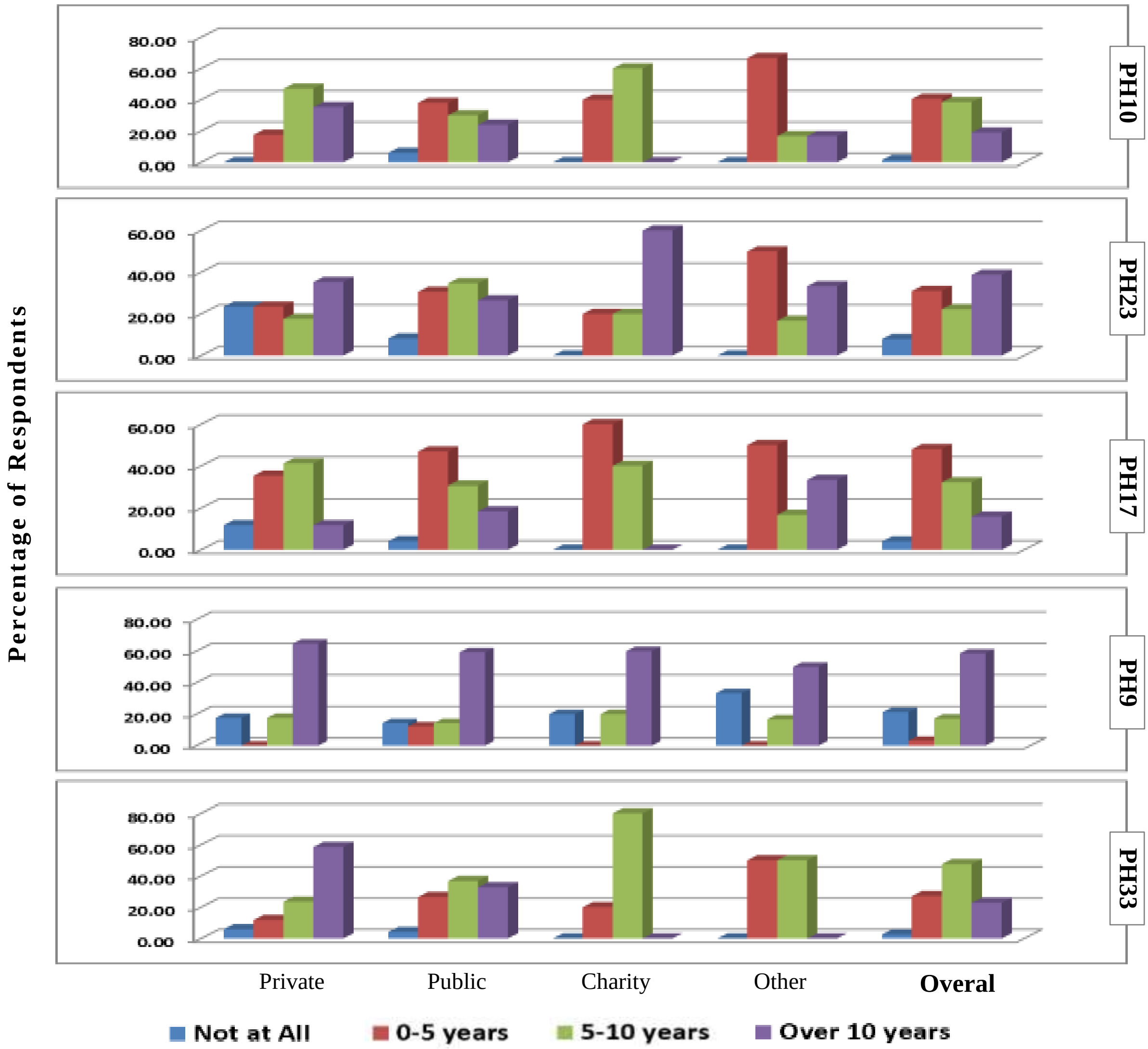

Figure 12-10 Timeframe for Physical Risks Based on Type of Organisation

The respondents from other organisations and sectors have shown that the occurrence time for **PH10 'Increased capital expenditures due to physical risks'** might range from 0–5 years, as illustrated in Figure 12-10 above. For the charity and private organisations, the timescale of occurrence is usually between 5 and 10 years in terms of the physical risk. For the public sector, it is possible for the effect to occur within 5–10 years or nearer the 0–5 year term. In regard to **PH23 'Increase in the cost of materials supplies'**, the impact could appear more than ten years in the charity sector, whilst the majority of respondents from other organisations consider that the impact could occur from 0–5 years. However, for the private and public sector, there was no clear agreement amongst the respondents indicating which timescale of the physical risks would emerge on buildings and real estate.

The physical risk **PH17 'Surface water flooding'** occurrence timeframe of impact seems to be present within 0–5 years, according to public, charity and other organisations. The respondents from the private sector found the effect to occur between 0 and 5 years, or in the long term of 5–10 years. For the **PH9 'Potential need for retrofitting mechanical ventilation'**, the majority of the respondents from the organisations agree that the impact would appear across more than ten years on buildings and real estate. Regarding **PH33 'Erosion of historic building fabric'**, the impact could occur in 5–10 years for the charity organisation, whilst it would emerge after 10 years for the private sectors. The effect could be seen from 0–5 years and 5–10 years according to other organisations' respondents. For public organisations, the impact from this physical risk might emerge in 5 years to more than 10 years. It was clear that no particular agreement could be established between the organisations in terms of the occurrence timescale of the impacts emerging from the physical risks.

12.4.1.2 Timeframe Based on the Professional Role in Organisation

No clear pattern for the occurrence time effect has been seen by the professional roles in organisations in terms of **PH10 'Increased capital expenditures due to physical risks'**; however, it is possible to recognise that the impact generally emerged between 0–10 years, as shown in Figure 12-11. For **PH23 'Increase in the cost of materials supplies'**, the effect might start to appear after 10 years according to academic respondents and the real estate portfolio managers. Based on the facility managers, the effect could be witnessed between 0 and 10 years. The **PH17 'Surface water flooding'** might not occur at all, according to academic respondents, whilst it may occur between 0 and 5 years, in the view of the other roles, and between 5 and 10 years according to the real estate portfolio managers.

The **PH9 'Potential need for retrofitting mechanical ventilation'** was expected to emerge between 0 and 5 years, according to the real estate portfolio managers, whilst it may be seen after 10 years, according to the facility managers and other professionals. The physical risk, which is **PH33 'Erosion of historic building fabric'**, was due after 10 years, according to the academics, whilst it was expected to occur between 5 and 10 years, by the real estate portfolio and risk managers.

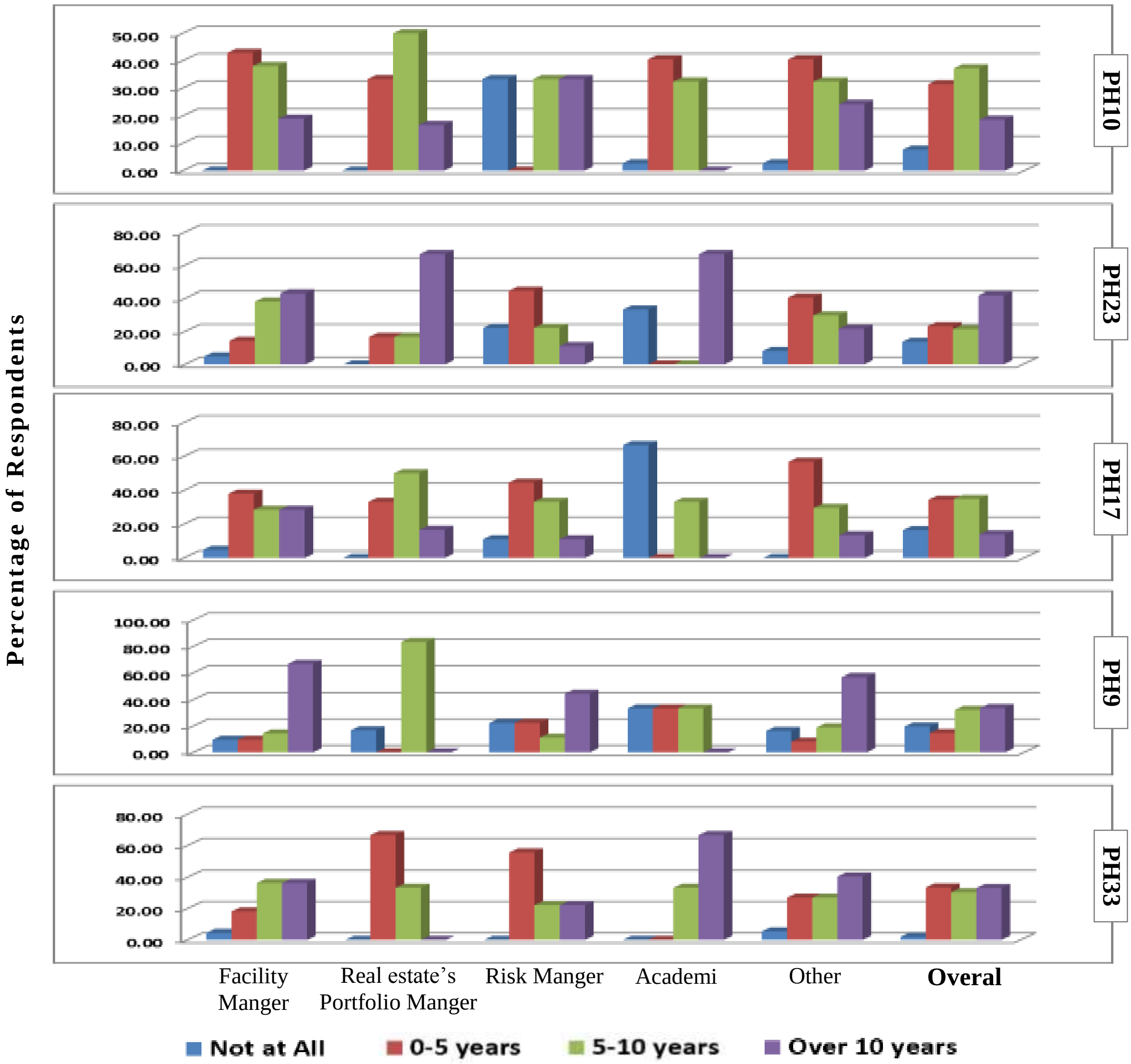

Figure 12-11 Timeframe for Physical Risks Based on Professionals Role in Organisation

12.4.2 Operational Risk Factors

12.4.2.1 Timeframe Based on the Type of Organisation

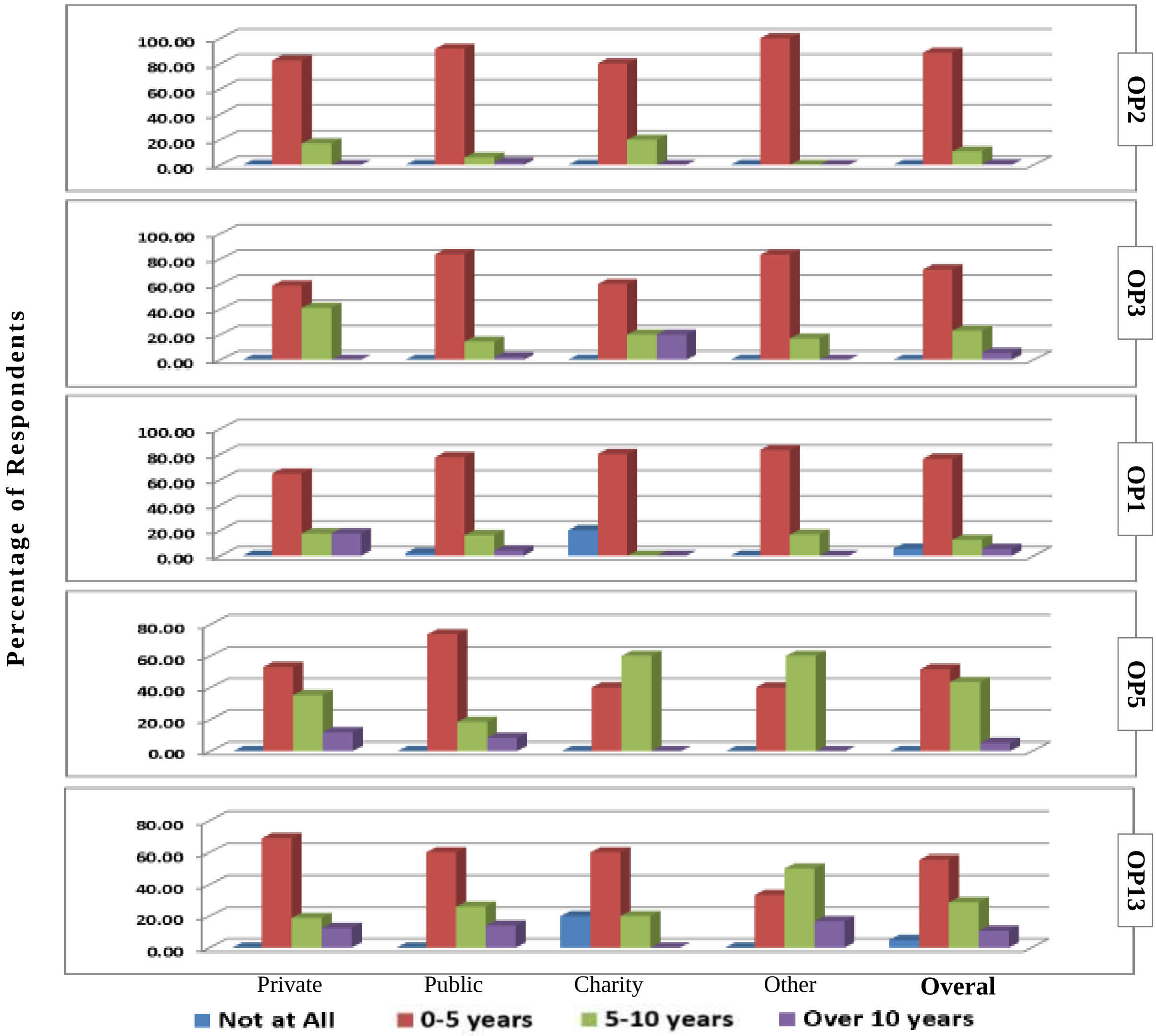

Figure 12-12 Timeframe for Operational Risks Based on Type of Organisation

For the operational risks **OP2 'Higher energy prices'**, **OP3 'increasing water costs'** and **OP1 'Increase in energy use'**, the impact could mainly be observed between 0 and 5 years by the whole organisation, as described in Figure 12-12. The **OP5 'Higher costs of repair'** was expected to occur between 0 and 5 years by the private and public organisations, whilst its impacts may appear between 5 and 10 years by the charity and other organisations. The **OP13 'Increase in the cost of waste water discharge'** is projected to arise between 0 and 5 years by the private, public and charity organisations, whilst it could occur between 5 and 10 years, based on the other organisations.

12.4.2.2 Timeframe Based on the Professional Role in Organisations

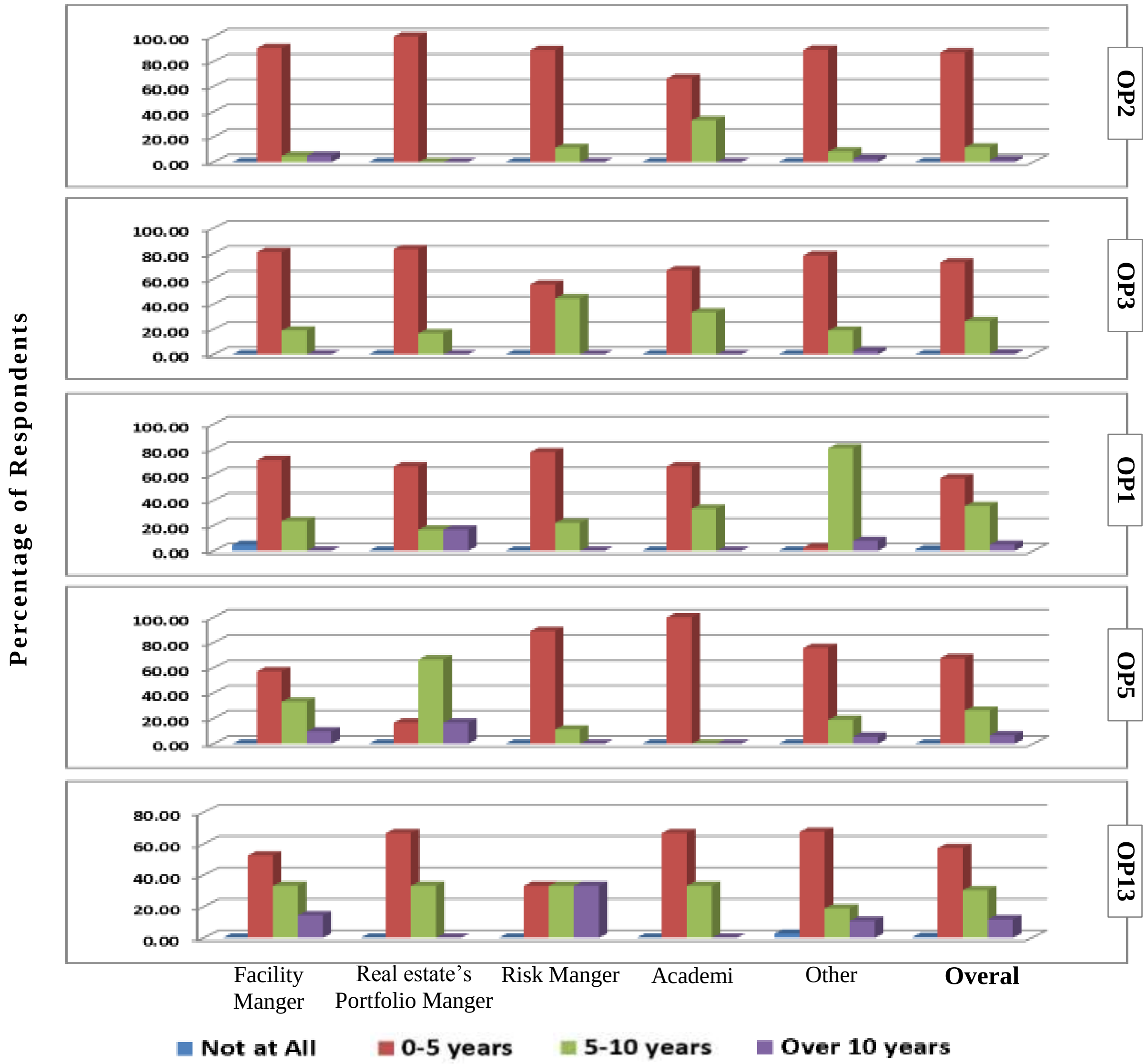

Figure 12-13 Timeframe for Operational Risks Based on Professionals Role in Organisation

From Figure 12-13, it can be seen that there was a clear pattern for the likelihood of emergence timescale of operational risks between 0 and 5 years for all five factors according to all professionals. Importantly, only the 'other' professionals showed the impact to appear in between 5 and 10 years for **OP1 'Increase in emergency use'**. Moreover, according to the risk managers, the **OP13 'Increase in the cost of waste water discharge'** may occur in a timescale ranging from 0–5 years to more than 10 years.

12.4.3 Financial Risks Factors

12.4.3.1 Timeframe Based on the Type of Organisation

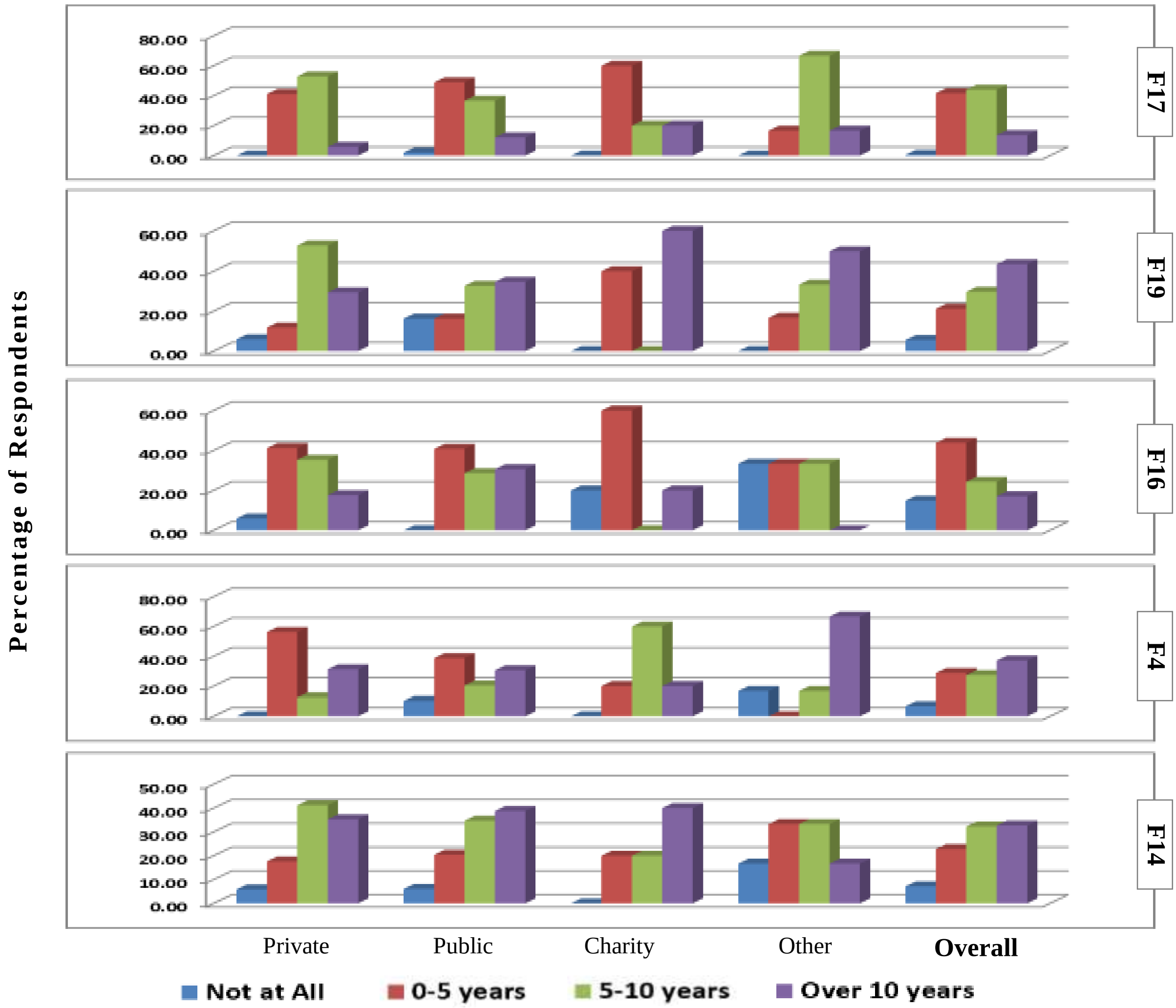

Figure 12-14 Timeframe for Financial Risks Based on Type of Organisation

Based on Figure 12-14, the respondents from other organisations showed that the occurrence timeframe in terms of **F17 'Increased insurance excess'** was mainly ranging from 5–10 years. The majority of respondents from charity and public organisations indicated that the impact might occur between 0–5 years. For the private sector, it is possible for the effect to appear in 0–5 years or 5–10 years. In terms of **F19 'Additional expense in insuring buildings in flood risk zones'**, the effect could occur over ten years for the charity and other organisations, whilst the majority of respondents from private organisation thought the effect could be arise between 5–10 years. The **F16 'Increase costs to purchase'** is expected to be observed between 0–5 years by the charity organisation, as well as in the overall view. On the other hand, the impact occurrence timescale is varied from one year and more than ten years for the remaining organisations. For **F4 'Increase in administrative expenses'** the effect could be after ten years for the other organisation, whilst it could be happen in 5–10 years for the charity and in 0–5 years for the private sector. The **F14 'Changing patterns of consumer demand'** is possible to occur between 5 and 10 years, and more than ten years for the private and public organisations, whilst this may occur between 0 and 5 years, and in the longer term (5–10 years) for other organisations.

12.4.4 Timeframe Based on the Professional Role in Organisations

Figure 12-15 shows that the **F17 'Increased insurance excess'** could appear in buildings and real estate at a timescale of between 0 and 5 years, based on academics and other professional respondents. According to risk managers and real estate portfolio management, the impact might emerge between 0 and 5 years and between 5 and 10 years. **F19 'Additional expense in insuring buildings in flood risk zones'** affects buildings and real estate in 5–10 years, based on the views of the academics, whilst its influence might observed after ten years by facility managers, risk managers and those in the 'other' role. This was followed by nearly the same respondents as real estate portfolio managers reported that the impacts appear in the timeframe of 0–5 years and 5–10 years. The **F16 'Increase costs to purchase'** could occur between 0–5 years, according to the risk managers and other professionals. On the other hand, however, it could arise between 5 and 10 years, based on real estate portfolio managers. The facility managers consider that the effect might emerge between 0 and 10 years. **F4 'Increase in administrative expenses'** is mainly observed between 0 and 5 years for academics and for more than ten years for real estate portfolio managers. **F14 'Changing patterns of consumer demand'** was expected to happen between 5 and 10 years, as based on the views of academics, whilst it was more than ten years for risk managers. Furthermore, it was more than 5 years for real estate portfolio managers.

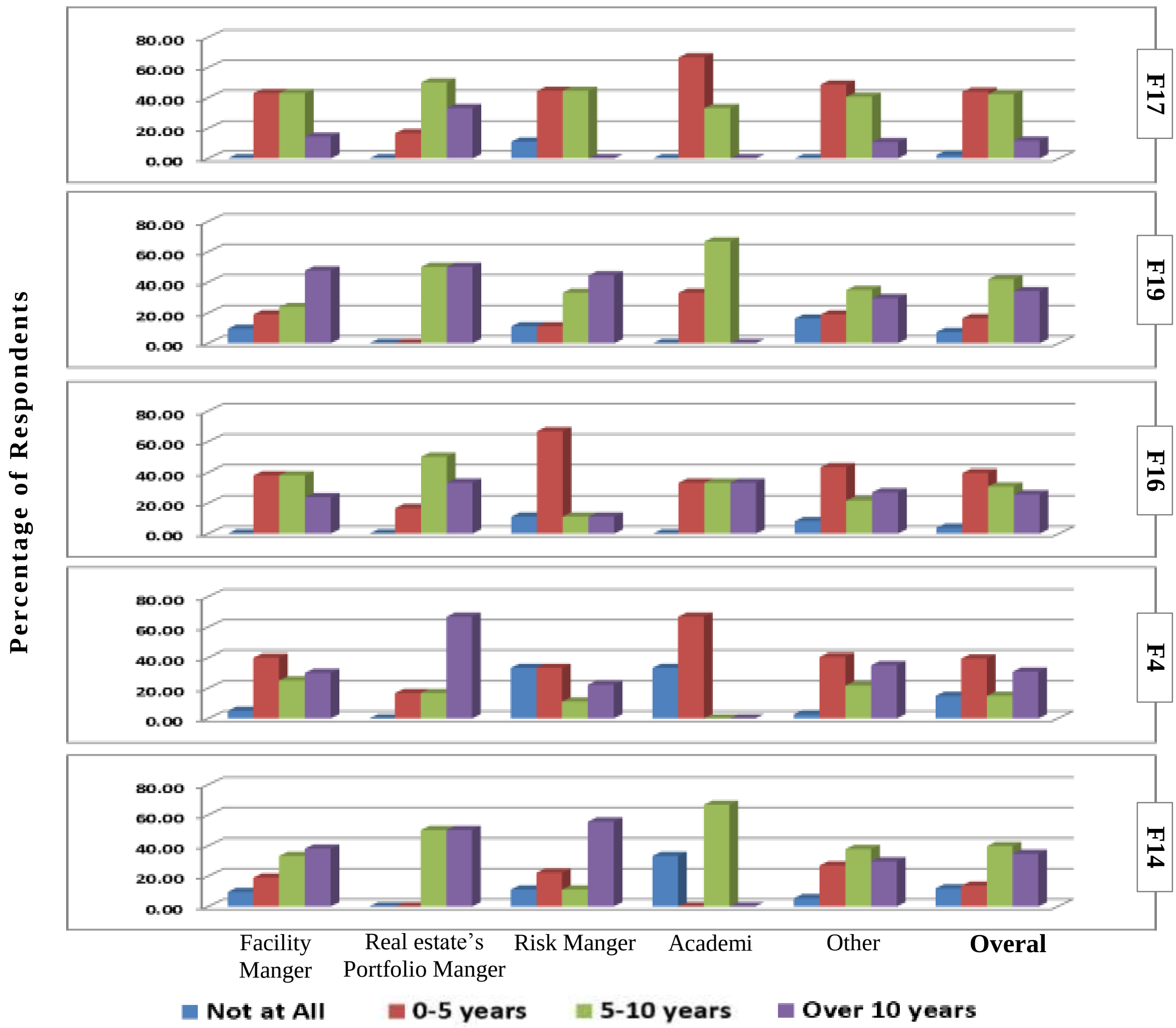

Figure 12-15 Timeframe for Financial Risks Based on Professionals Role in Organisation

12.4.5 Occupant Dissatisfaction Factors

12.4.5.1 Timeframe Based on the Type of Organisation

The majority of respondents from all organisations showed that the effect on buildings and real estate from **O1 'Thermal discomfort'** might range from 0–5 years, as illustrated in Figure 12-16. In terms of **O2 'Loss of productivity'**, the majority of the respondents from charity institutions thought that the impact would appear between 0 and 5 years, as well as in the private sector, whilst it is expected to arise in 5–10 years in the public sector. The **O3 'Heat related health risks'** could be observed between 0–5 years by charity and other organisations. On the other hand, the effect is projected to occur in more than 10 years for private organisations.

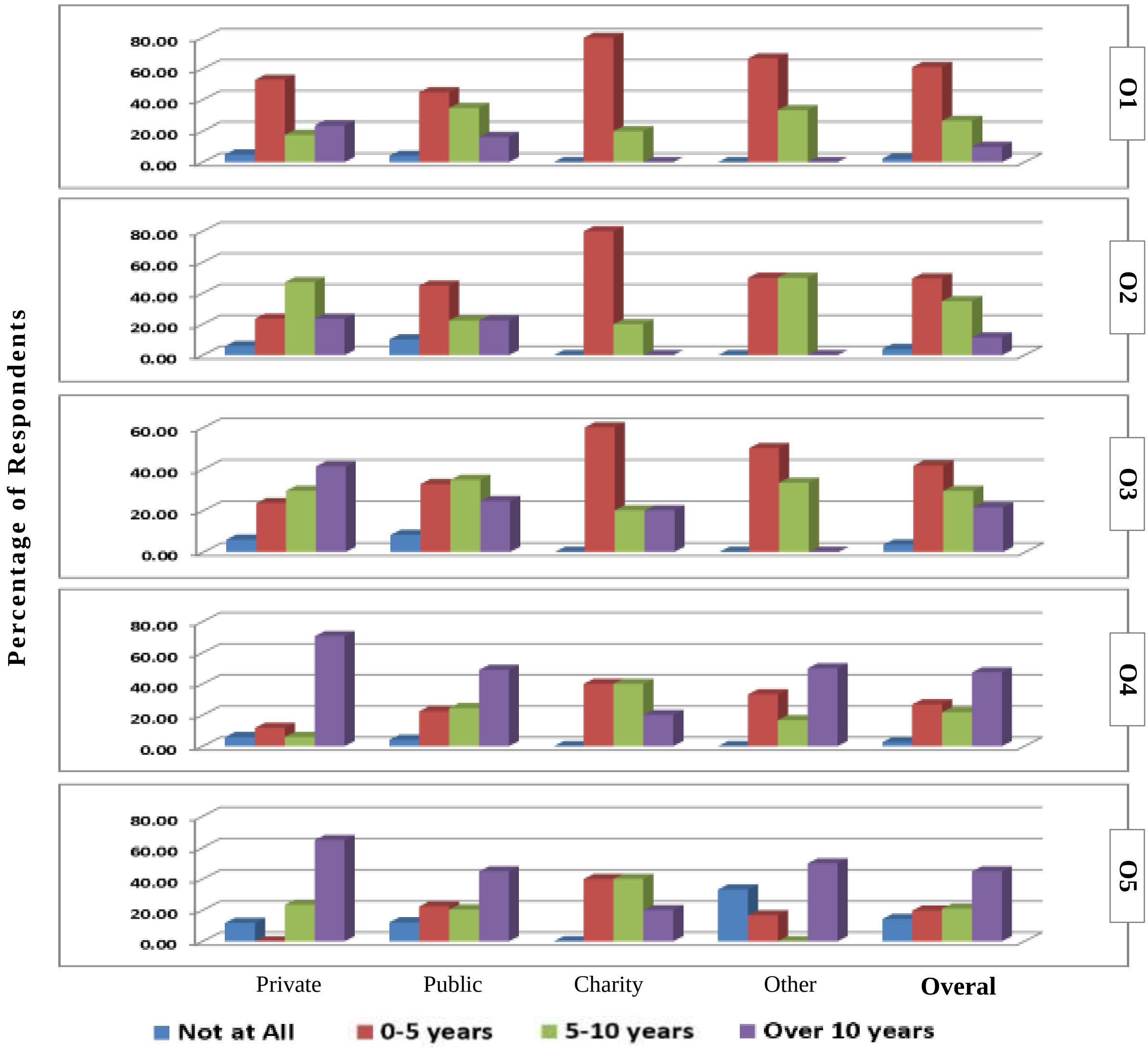

Figure 12-16 Timeframe for Occupants Dissatisfaction Factors Based on Type of Organisation

For **O4 'Usability of Buildings become impaired'**, the effect could be after ten years for private, public and other organisations, whilst it could be appear in a timeframe of between 0 and 5 and 5 and 10 years for the charity sector. The **O5 'Business continuity impaired'** is expected to occur in more than 10 years for the private, public and other organisations, whilst it may emerge in a timescale of 0–5 and 5–10 years for the charity institutions.

12.4.5.2 Timeframe Based on the Professional Role in Organisations

According to Figure 12-17, **O1 'Thermal discomfort'** could occur between 0 and 5 years, based on the facility managers, risk managers and other professionals, whilst it is projected to arise between 5 and 10 years for the real estate portfolio managers. The **O2 'Loss of**

productivity' might occur between 0 and 5 years, as reported by risk managers and other professionals, whilst it is expected to appear in 5–10 years, as claimed by facility managers; this is followed by academics and real estate portfolio managers. The **O3 'Heat related health risks'** could be observed between 5 and 10 years, as reported by facility and real estate portfolio managers, whilst it is projected to occur between 0 and 5 years, as based on risk managers and academics. The **O4 'Usability of Buildings become impaired'** might be observed after 10 years by all professional roles except academics, who consider that it could emerge in 5–10 years. Almost all of the respondents who worked as real estate portfolio manager expected that the **O5 'Business continuity impaired'** could be recognised after 10 years, followed by risk managers and other professionals. Overall, the O1 and **O2** might appear in a relatively close timescale (0–5 years); in contrast, the **O4** and **O5** could appear in far timeframe (over 10 years).

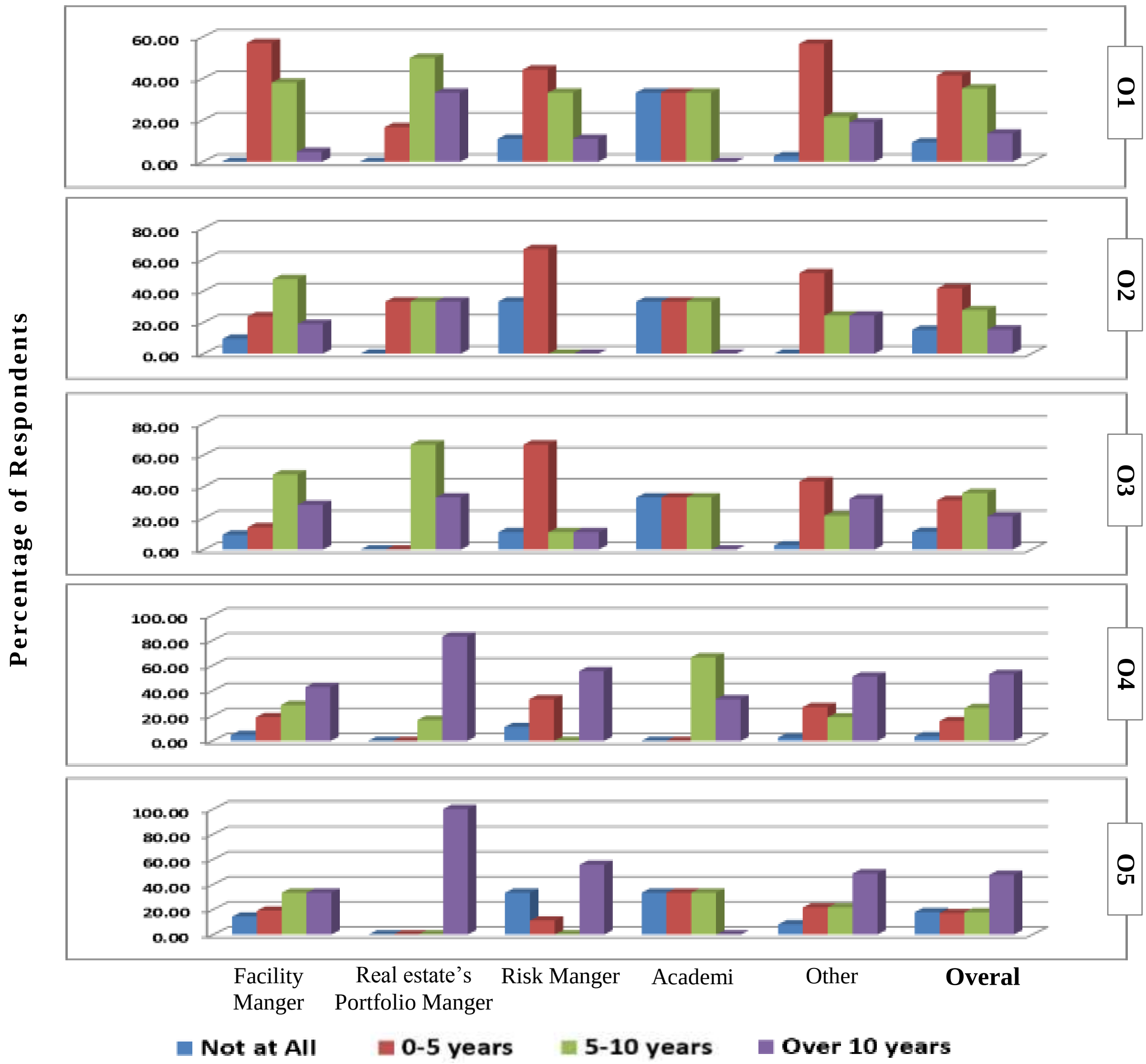

Figure 12-17 Timeframe for Occupants Dissatisfaction Factors Based on Professionals Role in Organisation

12.4.6 Liability and Responsibility Factors

12.4.6.1 Timeframe Based on the Type of Organisation

From Figure 12-18, the **LR4 'Increasing environmental litigation'** could occur after 10 years for private and public organisations, whilst it was expected to be more than 5 years for the charity and other institutions. According to all types of organisation, the **LR5 'Increasing decommissioning Litigation'** is expected to emerge after 10 years. The same result was obtained for the **LR6 'Professionals (advisers, designers, owners, tenant, insurers), which will bear the responsibility of maladapted new buildings'**, as other organisations think its impacts might emerge after 5 years. For **LR1 'Increase of recourse action against professional advisors'**, the influence could appear between 5 and 10 years for other organisations, whilst it was more than 10 years for charity organisations. It was more than 0–5 years and more than 10 years for public organisations. The **LR2 'Buildings dangerous to health as a result of high temperature'** could be observed after 10 years by private, public and other institutions. Across all respondents, these clusters of emerging risks might occur in more than ten years, as presented below.

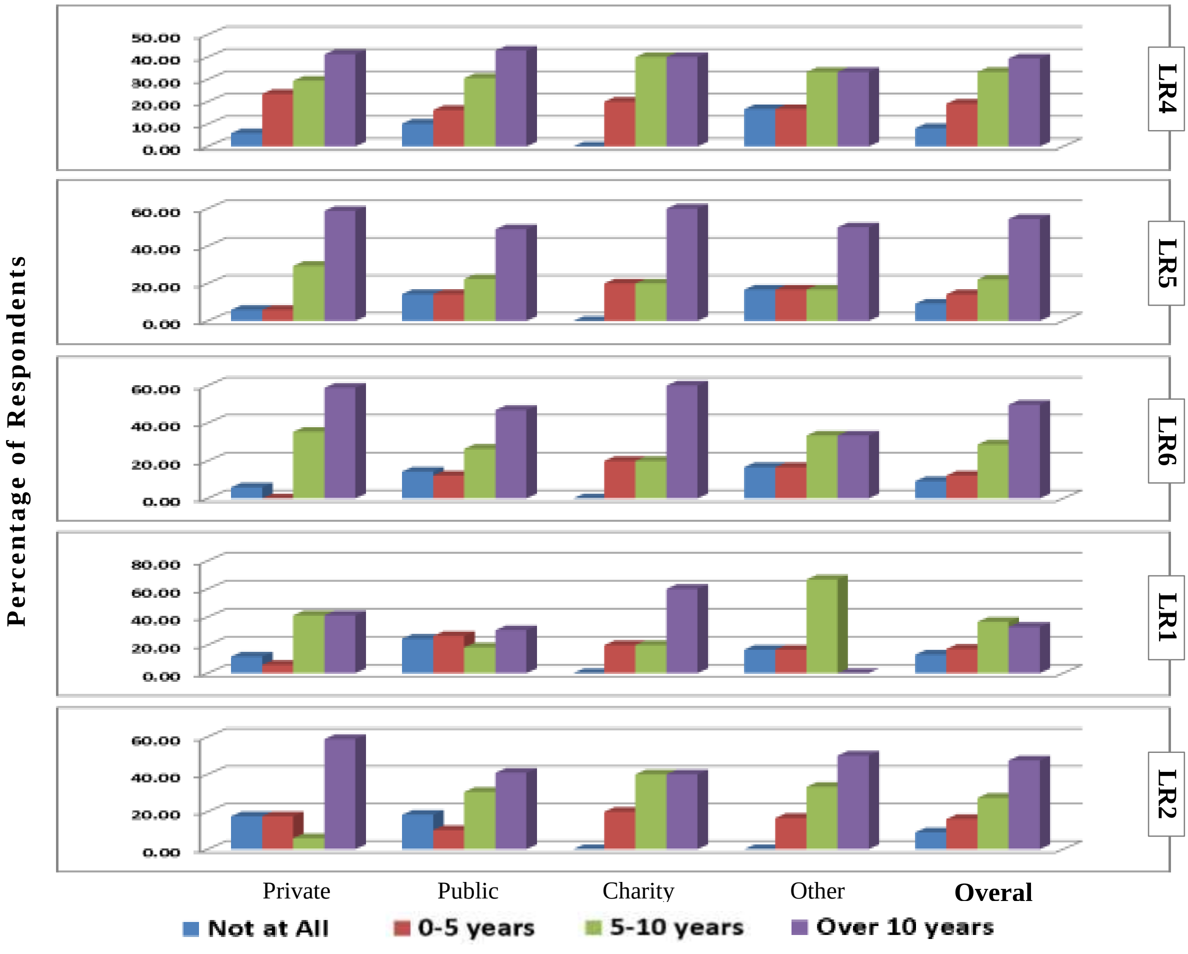

Figure 12-18 Timeframe for Liability & Responsibility Factors Based on Type of Organisation

12.4.6.1 Timeframe Based on the Professional Role in Organisations

The **LR4 'Increasing environmental litigation'** is projected by academics to occur on buildings and real estate after 10 years, and there is no occurrence timescale for this risk based on risk managers. Whilst it is expected that the impact to appear between 0 and 5 years, as reported by real estate portfolio managers, it is expected to be between 5 and 10 years by facility managers. For the **LR5 'Increasing decommissioning Litigation'**, the effect might be noticed as being between 5 and 10 years, as presented by the academics, whilst it was more than 10 years for the remaining professionals. For the **LR6 'Professionals (advisers, designers, owners, tenant, insurers), which will bear the responsibility of maladapted new buildings'**, the effect is projected to emerge in over ten years, based on the academics, risk and other managers, whilst it was more than 10 years for the real estate portfolio managers.

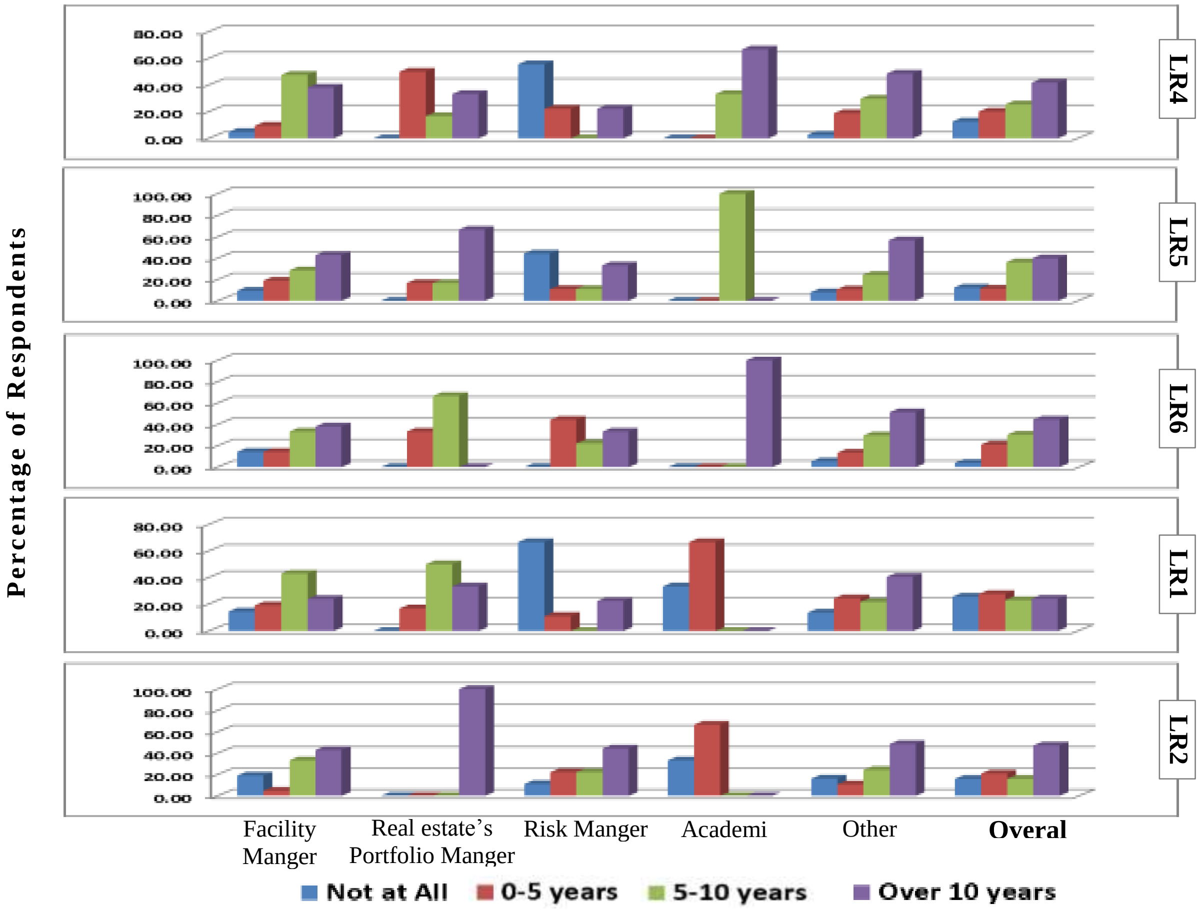

Figure 12-19 Timeframe for Liability & Responsibility Factors Based on Professionals Role in Organisation

The **LR1** is likely to occur between 0 and 5 years, as reported by academics, and between 5 and 10 years for real estate portfolio and facility managers; however, risk mangers claim that there are no expected occurrence timeframes for this risk. The **LR2 'Buildings dangerous to**

health as a result of high temperature' could be observed after 10 years by the real estate portfolio, facility managers and other professionals, whilst its impact projected to arise in 0–5 years is based on the views of academics, as illustrated in Figure 12-19. Moreover, there are clear agreements to be made between respondents, as overall it is noted that these emerging risks might emerge in more than ten years.

12.4.7 Reputational Risk Factors

12.4.7.1 Timeframe Based on the Type of Organisation

The majority of respondents from public, private and charity organisations present that the effect on buildings and real estate from **R13 'Increased carbon emissions'** might appear in a timescale of 0–5 years, whilst other sectors project this to arise in in 5–10 years, as illustrated in Figure 12-20. In terms of **R9 'Higher liability risks'**, the majority of respondents amongst all organisations consider that the impact of this factor might emerge in more than

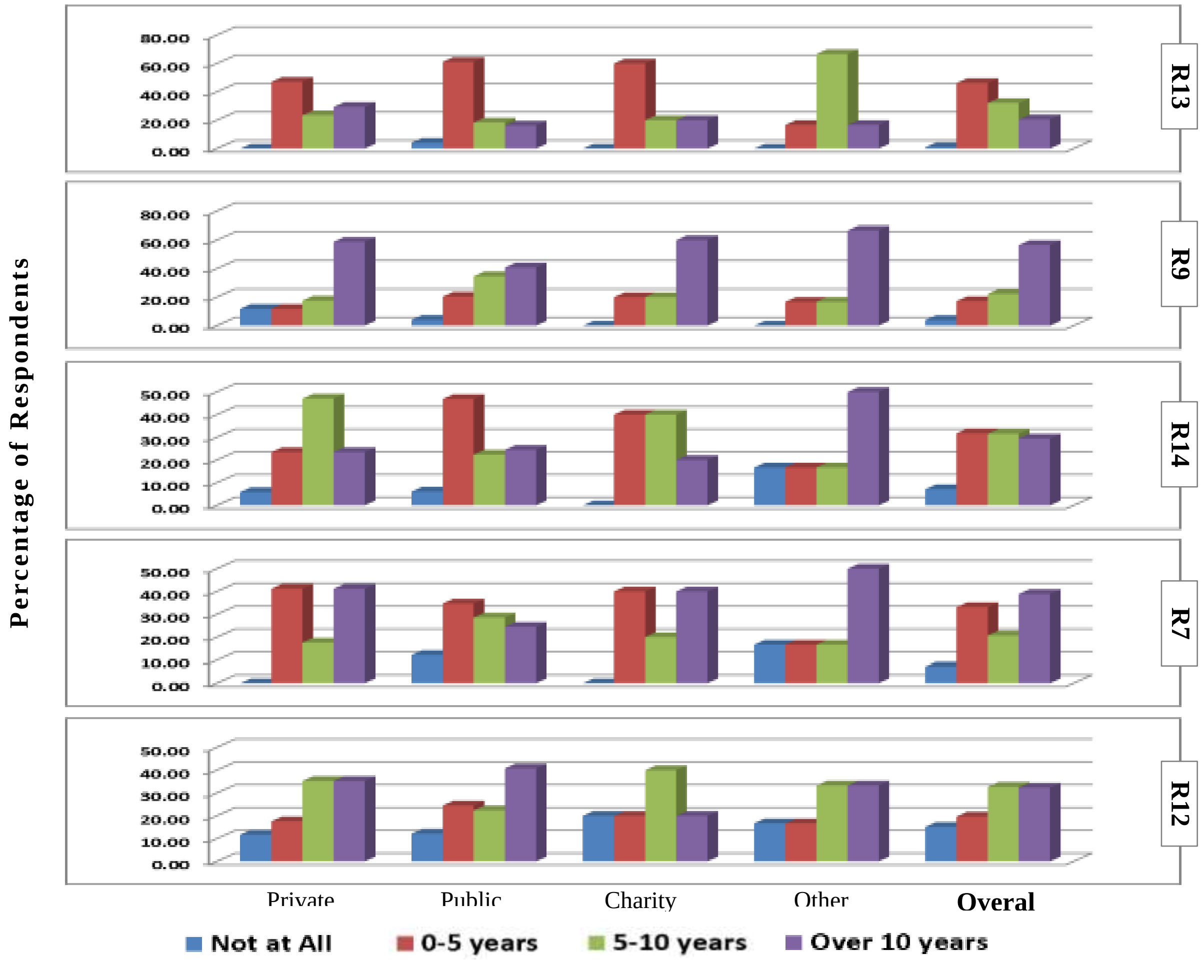

Figure 12-20 Timeframe for Reputational Risks Factors Based on Type of Organisation

ten years. The **R14 'Increased level of staff stress'** is a difference between respondents from whole organisations, where the public sector expected the impact to appear in 0–5 years, whilst the private sector stated in 5–10 years, and charity organisations noted between 0 and 10 years; other organisations, on the other hand, projected the effect as arising in over ten years. The majority of the respondents from other organisations reported the **R7 'Higher economic risks'** as reputational risk, which might occur on buildings in over ten years, whilst the private and charity institutions indicated that the impact, in terms of reputational risk, would arise in a period of 0–5 years to more than ten years. For the **R12 'Increased sick days'**, the private sector and other organisations anticipated that the impact could arise between 5 and 10 years. In charity and public organisations, it was expected that the effect would occur in 5–10 years, and more than ten years sequentially.

12.4.7.2 Timeframe Based on the Professional Role in Organisations

The Figure 12-21 below shows that **R13 'Increased carbon emissions'** is expected to occur in a period of 0–5 years, based on facility, risk managers, academics and other professionals.

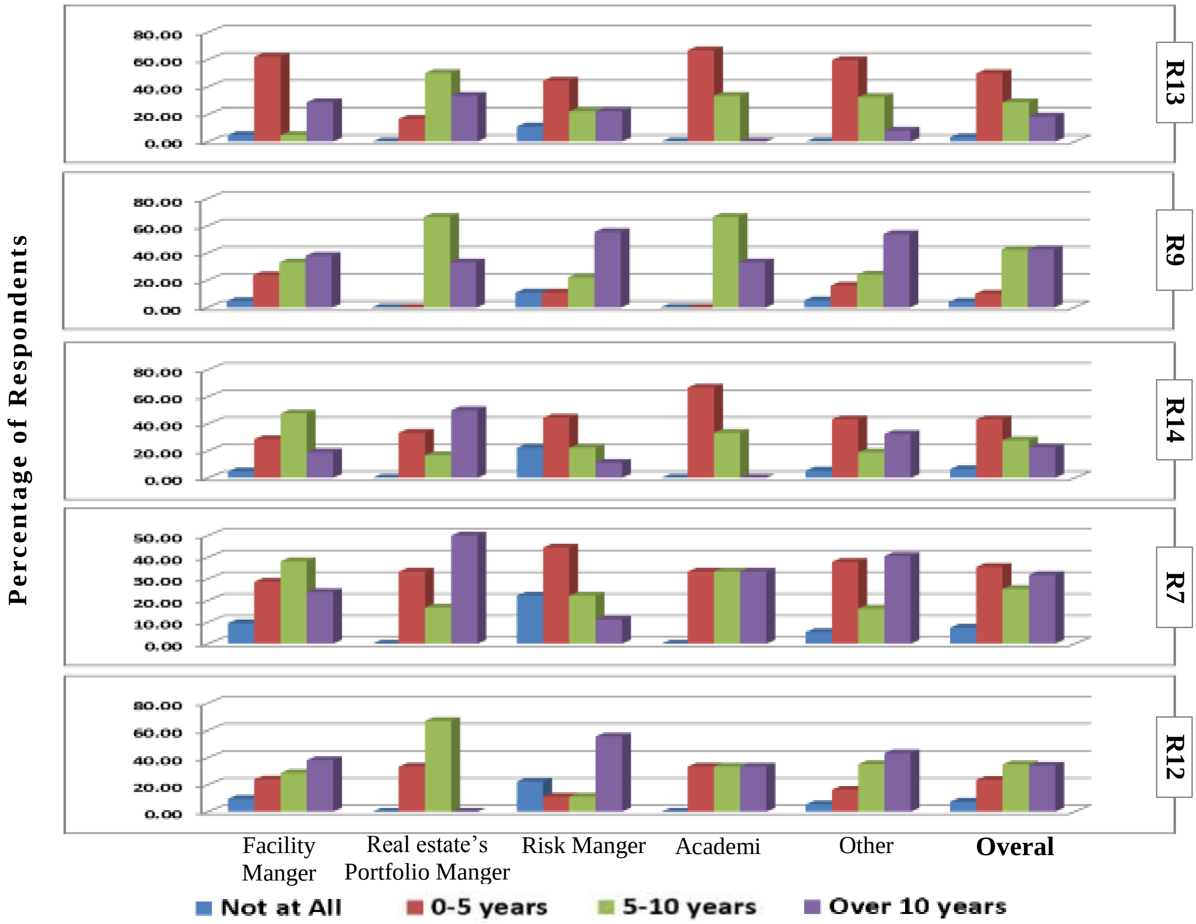

Figure 12-21 Timeframe for Reputational Risks Factors Based on Professionals Role in Organisation

Whilst real estate portfolio managers claim that the impact could appear in 5–10 years in terms of this risk. For **R9 'Higher liability risks'**, the impact could arise between 5 and 10 years, as reported by both the real estate portfolio managers and academics, whilst risk managers and other professionals agree that the effect might occur in long-term period (over 10 years).

According to **R14 'Increased level of staff stress'**, it is projected that its impact will be noted on buildings and real estate in the near term (0–5 years), as reported by risk managers, academics and other roles. It is highlighted as 5–10 years for facility managers and more than ten years, as claimed by real estate portfolio managers. For **R7 'Higher economic risks'**, there was no clear consent amongst all professionals; however, risk managers are expected to witness the impact in 0–5 years, whilst real estate portfolio managers and other roles indicate that it will be in the long-term, i.e. more than ten years. Based on the facility and risk managers and other professionals, it is expected that **R12 'Increased sick days'** will appear in buildings and real estate in more than ten years, whereas real estate portfolio managers report that the impact might occur earlier on, such as in 5–10 years.

12.4.8 Regulatory Risks Factors

12.4.8.1 Timeframe Based on the Type of Organisation

Almost all types of organisation indicate that **RE7 'Uncertainty of pending legislation on climate change'** is a regulation risk and expected to occur in the near-term (0–5 years), as illustrated in the Figure 12-22.

For **RE5 'Strict limits on greenhouse gas emissions'**, the private and public sector report that the impact might occur in 5–10 years, whilst charity and other organisations are expected to be in a long period of time, namely 5 years to more than ten years. This is followed by another agreement between the public and private sectors in terms of the timeframe for the impact of **RE6 'Mandatory climate change risk-appropriate building regulation'**, which is expected to occur in 5–10 years. For the **RE1 'Stringent regulation in relation to water stress'**, the impact is expected to occur in between 5 and 10 years, as reported by public and charity organisations, whilst this is highlighted as being over ten years in private and other organisations. According to the majority of organisations, the **RE2 'Stringent regulation in relation to flood stress'** is highly projected to appear in a period of 5–10 years, whilst it is expected to occur in between 5 years and more than ten years in other organisations.

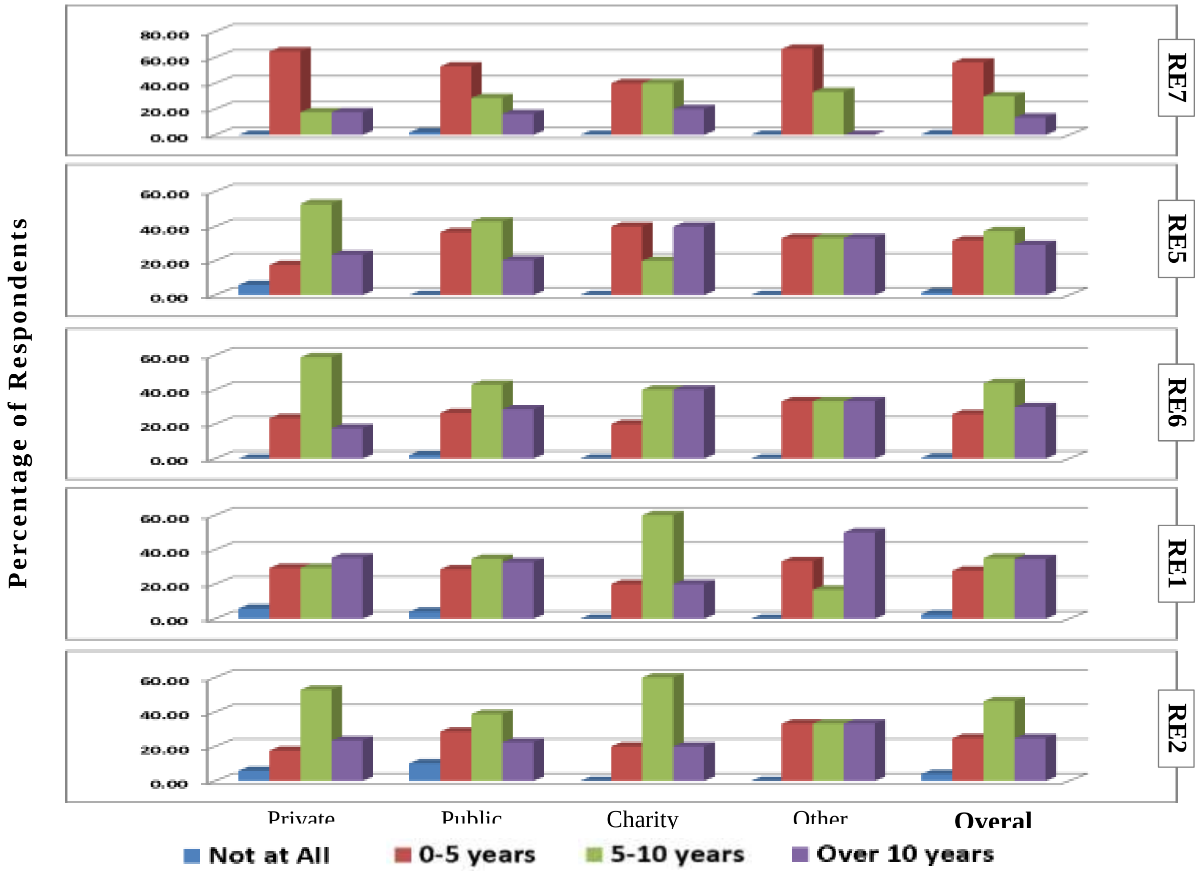

Figure 12-22 Timeframe for Regulatory Risks Factors Based on Type of Organisation

12.4.8.2 Timeframe Based on the Professional Role in Organisations

Figure 12-23 shows strong agreement amongst all professional roles concerning **RE7 Uncertainty of pending legislation on climate change'**, where the impact is expected to occur in the near-term (0–5 years).

For **RE5 'Strict limits on greenhouse gas emissions'**, the majority of risk mangers report that the impact might emerge in 0–5 years, whilst facility, real estate portfolio managers and other professionals present that the effect could occur in 5–10 years; there is no clear timeframe from academics. The **RE6 'Mandatory climate change risk-appropriate building regulation'** is projected by risk managers, academics and other roles as occurring on buildings and real estate in the near-term (0–5 years), whilst facility and real estate portfolio managers claim that the effect may arise in a period of 5 years to over ten years.

The **RE1 'Stringent regulation in relation to water stress'** could be observed after 10 years by other professionals, whilst its impact is projected to occur in 0–5 years, as based on risk and real estate portfolio managers. Facility mangers expect that the impact could occur in a timescale of 5–10 years; however, no clear agreement was established by academics in regard to the occurrence timeframe of this regulation risk. For **RE2 'Stringent regulation in relation to flood stress'**, it could occur in 5–10 years, as reported by real estate portfolio managers, whilst it is expected to appear after 10 years as claimed by risk and facility managers and other professionals. Moreover, no clear agreement was established by academics. However, overall, **RE7**, **RE6** and **RE1** are highly expected to appear on buildings and real estate in a timescale of 0–5 years, where the occurrence timescale for **RE5** and **RE2** is in 5–10 years.

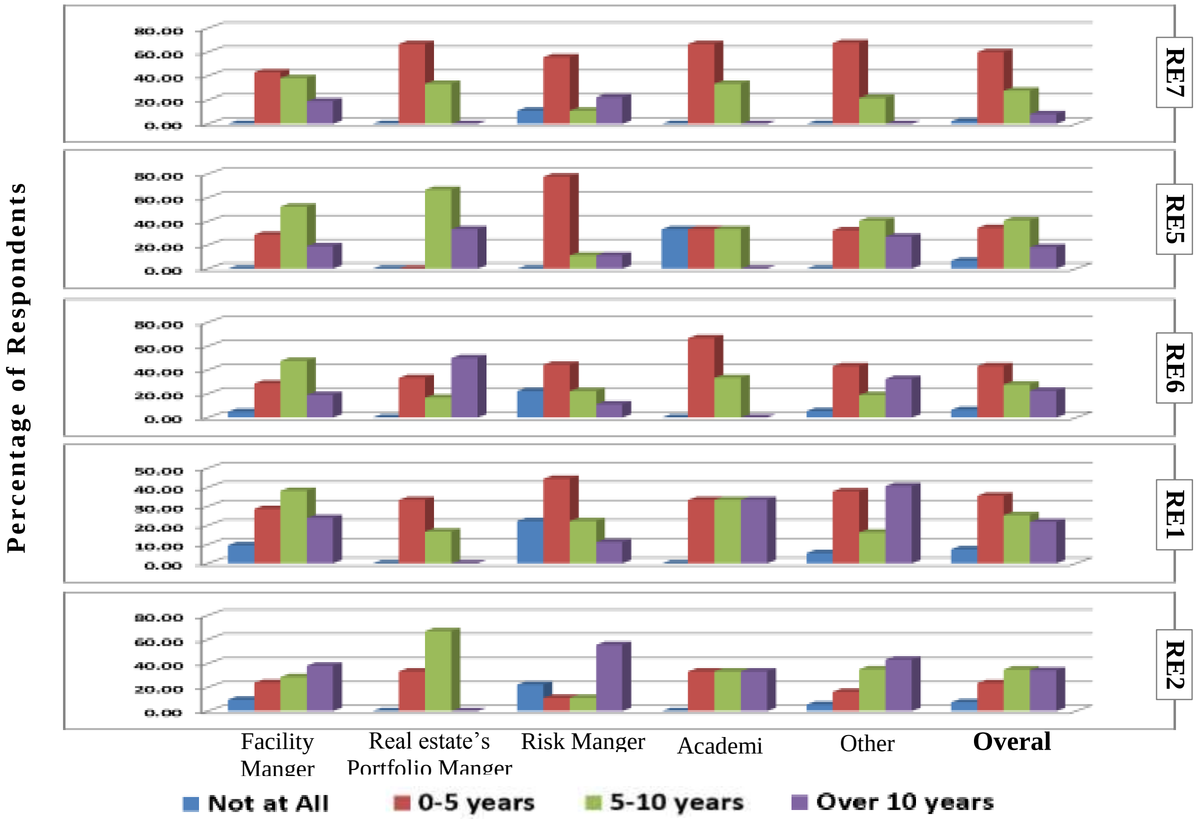

Figure 12-23 Timeframe for Regulatory Risks Factors Based on Professionals Role in Organisation

12.5 Summary of this Chapter

This chapter has illustrated and described the risks emerging from climate change scenarios on buildings and reals estate. This was based on the findings from the respondents, who represent various organisations and professional roles in the UK. The results have been described from a statistical perspective, starting with analysing the general information of the participants, including their roles and the type of organisation in which they are employed, as well as information relating to their views towards the axes of this study.

In addition, the analysis and evaluation of the various risks emerging from climate change patterns were based on the likelihood of these risks on buildings and real estate. This was followed by the selection of the top five risks from each climatic risk cluster in terms of their likelihood of occurrence. The selected risks have been discussed and described in terms of their occurrence timeframe, based on both perspectives of the type of organisations and the role type of the respondents.

Accordingly, the main findings from the analysis in this chapter show that the majority of the respondents from the public sector have more than 20 buildings and real estate under their management and control. Moreover, the results indicate that the most important emerging risks are operational risks in terms of both their occurrence likelihood and the timescale of their emergence; this result was expected as the most important phase in a building's lifecycle is the operation stage. In terms of the occurrence timeframe of the emerging risks, it is widely considered by the respondents that the majority of the identified risk factors might occur on the building sector in the short-term (0–5 years to 5–10 years), except the liability and responsibility risks, which would appear in more than 10 years.

The data and information gathered through the completion of the survey provides a valid and reliable foundation, resulting in the development and expansion of this study. The findings garnered and the overall results of the study have undergone critical analysis and evaluation; thus, this part of the study, in consideration to the validity and reliability of the data and findings, provides a guarantee for the overall success of this study as a whole.

CHAPTER 13: RANKING AND RATING THE FINDINGS AND ANALYSIS

13.1 Introduction

Identifying and knowing the risks arising from climate change scenarios on buildings and real estate constitute concern for the building sector. These climatic risks on the building sector can be a large set of risk factors. In the case of huge data in the researches, there is a need for ranking, as the case in this search project. Ranking and rating helps to accurately analyse the results and findings in order to make decisions in the selection and identification of common or similar indicators in this research. Ranking, in this research, is based on the list of risk factors, and comes in ranked order based on the level of importance and threat to the building sector, along with emergence timeframe. For the purposes of manageable discussion and also statistical significance, the type of organisations were abridged to three types, namely public, private and others; respondents from charity institutions were added into the ‘other’ type of organisation. Furthermore, concerning the professional roles, the real estate’s portfolio managers were add to risk managers; owners and academic respondents were added to the ‘other’ type of professional role.

Moreover, the ranking and rating of the emerging risks are based on the professional role of the respondents to the survey and the type of organisations by which they are employed. This chapter will explain and illustrate the statistical methods used to classify data that have been obtained from the questionnaire, which consists of 112 risk factors divided into seven different categories and 24 risk management factors. SPSS 21 and Microsoft Excel programs were adopted in the ranking and rating of the data so as to reach statistical features, such as average weighted mean, standard deviation, coefficient of variation, severity index and mean rank Kendall. This is illustrated and described in the following sections of this chapter.

13.2 Analysis and Ranking

There are various techniques and methods that can be used in order to analyse the data and findings from surveys; however, the first stage adopted centres on calculating a mean score for each risk factor, based on each respondent’s score. The mean weighted rating for each risk factor is computed so as to indicate the importance of each indicator. Equation 13.1 can be seen below.

$$\text{Mean weighted rating} = [\sum (R*F)] / n \qquad \textit{Equation 13.1}$$

where: R = rating of each risk factor (1,2,3,4,5)

F = frequency of responses

n = total number of respondents which is (78)

Severity index (S.I) measured in order to rank each risk factor according to their significance. Equation 13.2 presents how the S.I is calculated:

$$\text{Severity index (S.I)} = [(\sum W*F)] / n] * 100\ \% \qquad \textit{Equation 13.2}$$

where: W = weight of each rating (1/5, 2/5, 3/5, 4/5, 5/5)

F = frequency of responses

n = total number of respondents (n = 78)

The calculations of weighted mean and severity indices of indicators are presented in Tables Table 13.1 - Table 13.14 below.

Coefficient of Variation (COV) is the expression of standard deviation (SD) as a percentage of the mean; and is helpful when comparing the relative variability from various respondents. Coefficient of Variation (COV) can be computed using the Equation 13.3 below.

$$\text{Coefficient of Variation (COV)} = (S.D / M) * 100\ \% \qquad \textit{Equation 13.3}$$

where: S.D = standard deviation

M = weighted mean

The list of emerging risks derived from the literatures was provided to the respondents of the survey. They were asked to rate each risk in terms of the likelihood of the occurrence of risks on the building sector, using the Likert scale (very likely=1, likely=2, neutral=3, unlikely=4 and very unlikely=5). Furthermore, besides this question, the respondents were also asked to rate each risk factor's influences based on the timeframe of the probability of occurrence of CCR, using the timescale (Not at all=0, 0–5 years=1, 5–10 years=2 and over 10 years=3).

13.3 Rating and Ranking of Likelihood Occurrence of CCR

The following sections illustrate the statistical ranking of emerging climate change risks on buildings and real estate. Tables 13.1–13.7 rank the risk factors based on the results of both mean and standard deviation of risk factors, as well as the severity indices. In addition, in each table, the ranking is presented based on the professional roles in organisations and the type of organisation of the respondents, along with Kendall, category and overall ranking. In order to emphasise the emerging risks based on the ranking result of their likelihood occurrence on the building sector, the first five ranked risks factors have been selected in each cluster. Overall, 30 of the 112 (equal to approximately 25%, which is considered an adequate percentage) of the total emerging risk factors represented as the top risk factors were highlighted in Tables 13.15 and 13.16 later in this chapter. The results and description of the ranking and rating are illustrated in the following sections.

13.3.1 Physical Emerging Risks

The physical risks of CCS on the building sector consist of 37 risk factors. The average weighted mean in this cluster of emerging CCR varies from 1.95 to 3.46. Moreover, the severity indices range between 38.97% and 69.23%, which indicates their level of occurrence as an emerging physical risk. The ranking results in Table 13.1 shows that there are six factors—**PH9 (Potential need for retrofitting mechanical ventilation), PH10 (Increased capital expenditures due to physical risks), PH17 (Surface water flooding), PH23 (Increase in the cost of materials supplies), PH32 (Increase of damp, condensation and mould problems in buildings) and PH33 (Erosion of historic building fabric)**—with ranking amongst the first 30 ranked indicators. In Table 13.1, factor **PH10 'Increased capital expenditures due to physical risks'** is considered the highest ranked indicator for the physical risks that resulting from climate change on buildings and real estate, with the mean of 1.95 and severity index of 38.97%. It has an overall ranking of 11th out of 112; facility managers ranked 9th out of 112; risk managers ranked 12th out of 112; and other professionals ranked 17th out of 112. Whilst the private sector ranked 16th out of 112, the public sector ranked 14th out of 112, and other sectors ranked 8th out of 112.

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of Variation	Severity Index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
PH1	3.06	1.061	34.67	61.28	71.71	27	100	84	93	102	109	87	110
PH2	3.32	.987	29.73	66.41	79.94	34	109	111	102	109	108	107	112
PH3	2.65	.909	34.30	53.08	60.83	17	67	65	44	83	82	63	47
PH4	3.22	.976	30.31	64.36	79.91	33	107	103	86	108	106	105	109
PH5	2.97	.993	33.43	59.49	71.23	24	95	77	108	95	111	78	101
PH6	2.88	.993	34.48	57.69	69.05	23	88	88	59	92	93	84	94
PH7	2.85	1.106	38.81	56.92	67.44	22	84	95	32	91	76	90	71

PH8	2.60	.998	38.38	52.05	59.53	16	64	82	11	68	67	56	55
PH9	2.06	.873	42.38	41.28	42.31	4	18	16	23	16	24	16	16
PH10	1.95	.866	44.41	38.97	37.45	1	11	9	12	17	16	14	8
PH11	2.46	1.002	40.73	49.23	54.55	12	44	32	65	45	27	53	41
PH12	3.08	.937	30.42	61.54	75.69	28	101	105	45	101	95	100	105
PH13	3.13	.985	31.47	62.56	77.14	30	104	110	34	106	96	104	107
PH14	3.03	.993	32.77	60.51	73.64	25	97	107	24	99	91	101	83
PH15	2.77	.966	34.87	55.38	65.06	20	76	97	19	88	73	80	63
PH16	2.76	1.034	37.46	55.13	64.41	19	74	87	25	90	62	76	87
PH17	2.03	1.044	51.43	40.51	37.78	3	17	24	5	19	25	18	3
PH18	2.56	1.169	45.66	51.28	57.48	15	58	64	20	74	102	50	21
PH19	2.54	1.041	40.98	50.77	57.97	14	57	63	35	61	74	57	26
PH20	2.36	1.116	47.29	47.18	50.15	7	32	42	13	50	50	37	25
PH21	2.53	1.181	46.68	50.51	55.62	13	54	80	37	44	64	62	17
PH22	2.41	.986	40.91	48.21	52.43	11	41	41	47	46	48	45	36
PH23	1.97	.967	49.09	39.49	39.12	2	14	6	39	18	10	17	14
PH24	3.44	1.135	32.99	68.72	84.06	36	111	109	111	111	107	112	99
PH25	3.36	1.057	31.46	67.18	82.92	35	110	92	110	112	105	110	91
PH26	3.04	.999	32.86	60.77	73.10	26	98	85	88	100	99	102	64
PH27	2.38	.970	40.76	47.69	51.51	8	36	35	31	43	53	29	42
PH28	3.15	.927	29.43	63.08	77.39	31	105	101	83	107	97	106	103
PH29	2.82	.864	30.64	56.41	66.29	21	81	86	61	81	84	77	86
PH30	3.15	1.082	34.35	63.08	75.95	32	106	108	63	105	104	103	102
PH31	2.67	1.028	38.50	53.33	60.77	18	68	70	52	69	79	74	34
PH32	2.35	.895	38.06	46.92	48.45	6	30	27	27	47	32	40	22
PH33	2.15	.839	39.02	43.08	43.63	5	21	23	8	28	55	15	29
PH34	3.10	1.027	33.13	62.05	74.92	29	102	102	60	104	110	96	80
PH35	3.46	1.065	30.78	69.23	85.56	37	112	112	107	110	112	111	100
PH36	2.38	1.131	47.52	47.69	50.44	9	37	31	18	57	52	35	40
PH37	2.41	.918	38.09	48.21	53.64	10	39	48	21	48	80	23	51

Table 13.1 Ranking of Likelihood Occurrence for Emerging Physical Risks

Generally, there is consensus amongst all professionals regarding the five most important emerging physical risks, which are **PH9, PH10, PH17, PH23** and **PH33;** these can be considered in the six factors selected in the list of the top 30 emerging risks, except 32 based on the ranking. Similarly, in terms of the type of organisation, there is agreement that the most important physical risks arising from CCS are **PH9, PH10, PH17** and **PH23**.

On the other hand, the lowest ranked physical risk is **PH35 'Slope instability'**, which is ranked as the last important emerging risk factor, and which comes at the bottom of the list's concern of facility managers and private organisations. Subsequently, the following two physical risks ranked in lower concern are **PH24 'Saline water intrusion'** and **PH25 'Corrosive saline atmospheric exposure'**. The **PH24** was ranked by the public sector as the least physical risk and **PH25** was found to be at the bottom concern list of other professional roles.

13.3.2 Operational Emerging Risks

Operational risk is the second cluster of the emerging risks on buildings and real estate from CCS. The operational risks consist of 18 risk factors. Table 13.2 below presents 11 out of 18 risk factors as being ranked amongst the first 30 indicators, namely **OP1 (Increase in energy use), OP2 (Higher energy prices), OP3 (Increasing water costs), OP4 (Water use restriction), OP5 (Higher costs of repair), OP6 (Increased maintenance regimes), OP7 (Electricity brownouts and blackouts), OP8 (Increased reliance on mechanical cooling), OP13 (Increase in the cost of waste water discharge), OP15 (Increased costs due to alternative short-term supplies)** and **OP16 (Interruption of supply chain);** it includes the first six risk factors in the list of the first 30 risk factors. This means that almost two-thirds of the operational risks were ranked in the first 30 highest indicators, which further indicates the importance and concern of these emerging risks in the building sector.

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
OP1	1.62	.841	51.91	32.31	25.16	3	3	3	3	3	7	3	5
OP2	1.22	.474	38.85	24.36	14.66	1	1	1	1	1	1	1	1
OP3	1.29	.537	41.63	25.90	17.44	2	2	2	2	2	2	2	4
OP4	2.06	1.011	49.08	41.28	39.47	8	20	28	17	13	12	21	9
OP5	1.67	.715	42.81	33.33	27.97	4	4	5	7	4	6	4	11
OP6	1.77	.788	44.52	35.38	31.27	6	6	7	9	6	15	6	7
OP7	2.17	.813	37.47	43.33	44.75	9	22	18	29	21	13	25	23
OP8	1.95	.881	45.18	38.97	35.93	7	10	8	4	22	9	10	24
OP9	2.36	.868	36.78	47.18	49.96	12	33	20	53	39	21	32	53
OP10	2.87	.917	31.95	57.44	68.36	18	86	78	103	82	92	83	93
OP11	2.74	.889	32.45	54.87	64.28	16	73	69	84	73	85	68	79
OP12	2.54	.907	35.71	50.77	56.12	14	56	56	67	51	44	54	54
OP13	1.68	.637	37.92	33.08	29.40	5	5	4	6	7	4	5	28
OP14	2.58	.987	38.26	51.54	57.34	15	59	60	54	60	33	59	69
OP15	2.26	.859	38.01	45.13	48.03	10	23	44	42	20	20	24	39
OP16	2.33	.878	37.68	46.67	49.94	11	28	53	43	27	26	43	30
OP17	2.45	.907	37.02	48.97	53.05	13	43	49	55	42	30	46	61
OP18	2.79	.903	32.37	55.90	66.34	17	80	74	92	75	101	73	62

Table 13.2 Ranking of Likelihood Occurrence for Emerging Operational Risks

The weighted mean for the operational risk factors ranges from 1.22 to 2.87, along with their vary severity indices from 24.36% to 57.44%. In addition, the score of average weighted mean and the severity indices for all operational risks are very low in comparison with other emerging risks clusters. The risk factors **OP2, OP3, OP1, OP5, OP13** and **OP6** have an overall ranking of 1st to 6th out of 112 risks factors, respectively. Based on the professional role ranking, there is an agreement amongst all professionals concerning the first three emerging operational risks, namely **OP2, OP3** and **OP1.** Moreover, the respondents also held the view that these risk factors are the first three crucial emerging risks out of 112. Furthermore, in terms of ranking by type of organisation, there is agreement that the most likely occurrence of emerging operational risks is **OP2 'higher energy prices',** with a mean of 1.22 and severity index of 24.36%. The results obtained from this survey confirm that the emerging operational risks are the most important group of risks in terms of their likelihood of occurrence on buildings and real estate. These concerns are supported by Defra (2012) and Hertin *et al.,* (2003), who claim that the CCS will have a significant impact on assets operation processes, leading to increased concern of related mangers. On the other hand, the operational risks not ranked highly are **OP10 (Reduced access to infrastructure), OP18 (Increased slips and falls)** and **OP11 (Reduced access to facilities)**, whilst **OP10** is observed as the lowest ranked operational risk factor in terms of its likelihood of occurrence.

13.3.3 Financial Emerging Risks

This category consists of 23 risks emerging from climate change scenarios as financial risks in the building sector. In Table 13.3 below, there are just three financial risks in the group, which are ranked amongst the top 30 indicators, namely **F16 'Increase costs to purchase', F17 'Increased insurance excess',** and **F19 'Additional expense in insuring buildings in flood risk zones'.** These financial risks means are 2.03, 1.79 and 1.96 successively. Moreover, their severity indices are 40.51, 35.90 and 39.23. **F17** has the highest mean and severity index, as well as the highest overall ranking within this risks cluster, along with the top ten risks factor in the list of the first 30 top indicators, ranked 7th out of 112 emerging risks.

According to the ranking results based on professional role in the organisation, there is consensus concerning the first four financial risks in their ranking list within this group, namely **F4 'Increase in administrative expenses', F16, F17** and **F19**. Moreover, the private and public organisations held the same view, with other organisations agreeing on just **F17** and **F19**; however, the **F2 'Unable to repay debts'** ranked as the lowest financial risk factor as facility managers and risk managers ranked it as 106 out of 112; other professionals and the private sector, on the other hand, positioned it in place of 103 on their concerned list. Moreover, public and other organisations hold almost the same view, where the public sector ranked it as 109, whereas other organisations 108 out of 112 emerging risk factors from CCS.

In addition, the next two lowest ranked financial risks are **F21 'un-insurability due to climate change'** and **F9 'businesses become less competitive'.**

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of Variation	Severity Index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
F1	2.60	.921	35.42	51.28	59.10	10	63	59	62	58	65	52	70
F2	3.23	.992	30.71	64.62	79.21	23	108	106	106	103	103	109	108
F3	2.97	.882	29.70	59.49	71.54	19	94	89	96	94	81	97	73
F4	2.36	.897	38.01	47.18	50.92	5	34	37	46	34	19	41	52
F5	2.91	1.047	35.98	58.21	68.71	18	92	98	72	89	70	94	98
F6	3.00	1.044	34.80	60.00	72.22	20	96	94	104	96	66	99	104
F7	2.59	1.074	41.47	51.79	56.84	9	61	73	64	56	22	69	78
F8	2.68	1.051	39.22	53.59	60.39	13	69	68	81	63	57	70	82
F9	3.05	.992	32.52	61.03	70.73	21	99	96	94	97	90	95	111
F10	2.64	1.105	41.86	52.82	57.59	12	66	61	58	66	56	66	66
F11	2.87	1.109	38.64	57.44	67.29	16	87	99	71	80	100	86	76
F12	2.77	1.056	38.13	55.38	63.57	14	78	76	85	65	77	85	49
F13	2.88	.911	31.63	57.69	68.86	17	89	93	98	77	86	92	77
F14	2.36	.911	38.60	47.18	51.40	4	31	40	68	26	40	38	32
F15	2.46	.935	38.01	49.23	52.96	6	45	38	76	35	41	44	56
F16	2.03	.953	46.95	40.51	38.66	3	16	12	40	15	14	9	50
F17	1.79	.762	42.57	35.90	30.45	1	7	10	10	8	5	7	15
F18	2.51	1.090	43.43	50.26	56.00	7	52	55	57	53	28	60	44
F19	1.96	1.062	54.18	39.23	36.93	2	13	15	15	14	3	26	2
F20	2.58	.974	37.75	51.54	58.70	8	60	50	26	85	31	72	35
F21	3.12	1.162	37.24	62.31	74.90	22	103	104	79	98	83	108	96
F22	2.62	1.084	41.37	52.31	58.39	11	65	33	82	67	71	61	43
F23	2.83	1.156	40.84	56.67	65.21	15	82	83	87	84	68	91	85

Table 13.3 Ranking of Likelihood Occurrence for Emerging Financial Risks

13.3.4 Occupant Dissatisfaction Emerging Risks

The occupant dissatisfaction risks comprise six emerging risk factors, all related to occupants' safety, comfort and activity within buildings and real estate. The average weighted mean in this cluster of emerging climate change risks varies from 1.94 to 2.76, whilst the severity indices range changes from 38.72% to 55.13%, as shown in Table 13.4 below. According to the overall ranking, just two of these group indicators belong to the first 30 ranked emerging risks resulting from climate change scenarios. These two highest ranked risk factors are related to **O1 'thermal discomfort'** and **O2 'loss of productivity'**. This view could be expected as sectors and organisations seek to provide a suitable environment for their occupants in order to obtain the highest level of employee productivity; however, failure to provide such an environment or the necessary protection and safety for employees will result in a raised risk of potential occupant litigation. The third important risk factor in this cluster is **O3 'heat-related health risks'**, with an overall ranking of 35 and weighted mean of 2.38, along with severity index of 47.69%. Both facility managers and risk mangers held the same view in terms of the top emerging risks associated with occupant dissatisfaction, whilst the other professional role added **O5 'business continuity impaired'** to their top risk factors in this category; however, the lowest ranked risk factor in this cluster is **O6 'occupant litigation'**, which is almost ranked in the same place across the whole group of respondents.

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
O1	1.94	.958	49.38	38.72	35.09	1	9	11	22	11	18	11	6
O2	2.32	1.063	45.82	46.41	48.50	2	27	54	48	23	45	34	19
O3	2.38	1.060	44.54	47.69	50.67	3	35	58	56	29	58	33	31
O4	2.51	1.054	41.99	50.26	56.71	4	51	43	73	49	72	49	37
O5	2.72	1.172	43.09	54.36	62.59	5	71	72	90	64	88	71	60
O6	2.76	1.083	39.24	55.13	80.22	6	99	71	78	76	87	75	67

Table 13.4 Ranking of Likelihood Occurrence for Emerging Occupants Dissatisfaction Risks

13.3.5 Liability and Responsibility Emerging Risks

The liability and responsibility emerging risks include six risk factors, as illustrated in Table 13.5 below, where there is no risk factor ranked in the first 30 ranked risk factors. However, the highest ranked risk factor in this cluster is related to **LR4 'increasing environmental litigation'**, which is ranked in position 46 out of 112, with a mean of 2.47 and a severity index of 49.49%. Generally, the weighted mean through this risks category ranges from 2.47 to 2.95, whilst the severity index ranges from 49.49% to 58.97%. On the other hand, the **LR3 'increase of claims in contract or tort because buildings designed, or operated in a way that has insufficient regard to the reasonably anticipated impacts of climate change'** is observed as the lowest ranked risk factor in this group of emerging risks; it is ranked 93 out of 112 risk factors, and is ranked by risk managers as the least important factors.

The result in Table 13.5 concerning the liability and responsibility emerging risks indicate that there is no fear of this kind of risk emergence throughout all types of organisation and all professional roles surveyed. These could be due to the lack of understanding of responsibility at different levels of professional, sector and occupant related to emerging risks arising from climate change scenarios on the building sector.

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
LR1	2.78	1.101	39.60	55.64	64.82	4	79	62	101	78	63	82	81
LR2	2.83	1.037	36.64	56.67	67.12	5	83	90	36	93	89	88	46
LR3	2.95	1.080	36.61	58.97	68.16	6	93	79	112	86	75	98	65
LR4	2.47	.977	39.55	49.49	53.35	1	46	34	80	41	23	64	33
LR5	2.59	1.037	40.04	51.79	57.66	2	62	25	105	59	29	67	59
LR6	2.73	1.028	37.66	54.62	62.30	3	72	66	89	72	51	79	84

Table 13.5 Ranking of Likelihood Occurrence for Emerging Liability & Responsibility Risks

13.3.6 Reputational Emerging Risks

As for reputational risks, only 3 of the 15 factors in this emerging risks cluster were in the first 30 top ranked indicators, namely **R13 'increased carbon emissions', R9 'higher liabilities risk'** and **R14 'increased level of staff stress'**. The weighted mean for these factors were 2.28, 2.06 and 2.35, along with the severity index of 41.28%, 45.64% and 46.92%, respectively. In addition, all three of these factors have an overall ranking of 19th, 25th and 29th, respectively.

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
R1	2.54	1.028	40.47	50.77	55.78	11	55	45	74	52	43	51	75
R2	2.50	.964	38.56	50.00	53.92	9	50	26	69	54	54	39	90
R3	2.50	.908	36.32	50.00	55.99	8	49	47	50	55	35	55	45
R4	2.47	1.028	41.62	49.49	52.83	7	47	22	100	40	36	47	58
R5	2.90	.988	34.07	57.95	68.26	15	91	75	109	87	69	93	97
R6	2.88	1.093	37.95	57.69	66.89	14	90	91	99	79	78	89	95
R7	2.40	.985	41.04	47.95	51.62	4	38	36	66	32	46	28	74
R8	2.42	.890	36.78	48.46	52.86	6	42	29	70	37	39	42	57
R9	2.28	.737	32.32	45.64	48.70	2	25	17	49	33	47	22	38
R10	2.77	1.018	36.75	55.38	63.98	13	77	81	75	71	98	65	89
R11	2.69	.984	36.58	53.85	61.30	12	70	57	91	70	60	58	106
R12	2.41	.999	41.45	48.21	52.06	5	40	51	41	36	42	30	68
R13	2.06	.998	48.45	41.28	39.98	1	19	21	38	10	38	12	18
R14	2.35	.951	40.47	46.92	50.26	3	29	30	51	31	49	20	88
R15	2.51	.936	37.29	50.26	56.47	10	53	46	95	38	59	48	48

Table 13.6 Ranking of Likelihood Occurrence for Emerging Reputational Risks

There is no clear consensus amongst all professional roles, as shown in Table 13.6 below, as well as throughout all type of organisation. Furthermore, the lowest ranked risk factor in this cluster is **R5 'loss of investors'**, which is ranked overall as 91st out of 112 emerging risks. Furthermore, the next lowest are **R6 'lower staff retention and productivity due to building usability'** and **R10 'loss of potential customers due to business interruption'**; **R6** is observed at 90 and **R10** at 77 out of 112 emerging risk indicators.

13.3.7 Regulatory Emerging Risks

The regulation risks are the last cluster of risks emerging from climate change scenarios on buildings and real estate. The regulation risks comprise 7 risk factors, as presented in Table 13.7 below. Accordingly, there are 5 out of 7 regulation risk factors ranked amongst the first 30 indicators list, namely **RE1 'stringent regulation in relation to water stress'**, **RE2 'stringent regulation in relation to flood stress'**, **ER5 'strict limits on greenhouse gas emissions'**, **ER6 'mandatory climate change risk-appropriate building regulation'** and **RE7 'uncertainty of pending legislation on climate change'.** This means that approximately 70% of the regulation risks were ranked in the first 30 top indicators, suggesting the importance of the likelihood occurrence in the building sector. This importance and concern surrounding the regulation emerging risks is supported by the survey conducted by Knobloch and Leurig (2010), who established that the regulation risks from CCS are in the top risks of concern, as stated by 74.3% of their respondents.

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
RE1	2.27	.878	38.68	45.38	48.38	4	24	39	30	24	37	27	27
RE2	2.28	.992	43.51	45.64	47.37	5	26	52	28	25	34	31	20
RE3	2.49	.977	39.24	49.74	55.08	6	48	67	77	30	61	36	72
RE4	2.86	1.028	35.94	57.18	67.12	7	85	100	97	62	94	81	92
RE5	1.96	.844	43.06	39.23	37.39	2	12	13	16	12	17	13	10
RE6	2.01	.764	38.01	40.26	39.09	3	15	19	33	9	11	19	12
RE7	1.82	.802	44.07	36.41	42.33	1	8	14	14	5	8	8	13

Table 13.7 Ranking of likelihood occurrence for emerging regulation risks

Table 13.7 shows that there is an obvious consensus ranking for the first five important regulation risk factors amongst all professional roles, as well as throughout all types of organisation; however, the least ranked emerging risk in this cluster is **RE4 'stringent**

regulation in relation to windstorms stress', as it is observed at 85 out of 112 in the overall ranking. In addition, all groups of respondent held the same opinion about this factor with the exception of the other professional roles, who ranked this at 62 out of 112 emerging risks.

13.4 Ranking of the Timeframe of CCR Likelihood Occurrence on the Building Sector

Tables 13.8 to 13.14 illustrate the statistical rating and ranking of the timescale of the emerging climate change risks likelihood occurrence on the building sector based on the mean, standard deviation and magnitude of the severity indices. These tables present the rating and ranking according to the Kendall ranking, category and overall ranking, along with the ranking by professional role, as well as according to type of sector and organisation. The following sections explain and describe these ranking results.

13.4.1 Physical Emerging Risks

For emerging physical risks, ranking results in Table 13.8 show that 11 risks were ranked amongst the first top-30 ranked indicators by all categories of respondents, namely **PH2 'Potential for increased odour problems', PH17 (Surface water flooding), PH18 'Groundwater water flooding - from rising groundwater', PH20 'Water ingress to roofs', PH23 'Increase in the cost of materials supplies', PH24 'Saline water intrusion', PH25 'Corrosive saline atmospheric exposure', PH28 'Extreme exposure of building shell to dust', PH34 'Lightning strike damage to buildings during storms', PH35 'Slope instability'** and **PH36 'Insufficient roof drainage in storms'.**

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of Variation	Severity Index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
PH1	2.18	1.155	52.98	71.79	66.89	34	107	111	103	94	98	107	80
PH2	1.68	1.400	83.33	55.13	52.43	8	22	7	77	21	42	20	30
PH3	2.22	1.096	49.37	73.08	68.45	35	109	100	111	100	106	105	107
PH4	1.96	1.342	68.47	64.53	62.05	22	67	65	38	96	86	40	109
PH5	1.97	1.181	59.95	64.96	60.98	25	75	101	51	60	87	55	86
PH6	2.29	1.122	49.00	75.21	71.37	36	111	102	112	90	65	110	112
PH7	2.06	1.174	56.99	67.95	64.99	28	92	71	86	92	95	66	108
PH8	2.40	.877	36.54	79.06	73.06	37	112	112	109	112	110	112	104
PH9	1.99	.851	42.76	65.38	59.14	27	79	54	56	88	96	67	37
PH10	1.81	.859	47.46	59.40	52.87	15	40	35	49	38	84	32	20
PH11	1.87	.937	50.11	61.54	55.27	19	48	18	55	85	26	62	72
PH12	1.87	1.301	69.57	61.54	60.42	18	47	27	72	59	17	54	99
PH13	1.78	1.363	76.57	58.55	57.80	12	32	13	47	50	27	27	111
PH14	1.81	1.278	70.61	59.40	58.30	14	39	12	71	47	56	23	103
PH15	2.09	1.138	54.45	68.80	65.08	31	99	91	110	58	101	94	60

PH16	2.10	1.107	52.71	69.23	63.68	32	101	38	108	99	100	90	98
PH17	1.61	.830	51.55	52.99	46.25	3	16	45	16	12	8	21	25
PH18	1.65	.997	60.42	54.27	50.76	7	21	57	9	15	9	36	13
PH19	1.81	1.001	55.30	59.40	54.68	16	41	98	30	25	22	39	94
PH20	1.77	.985	55.65	58.12	53.21	11	30	96	41	19	31	29	93
PH21	1.79	1.068	59.66	58.97	54.35	13	35	31	66	32	4	46	92
PH22	1.99	.939	47.19	65.38	60.90	26	77	67	90	65	91	51	95
PH23	1.69	.892	52.78	55.56	49.98	9	24	23	78	16	15	30	40
PH24	1.45	1.372	94.62	47.86	47.53	1	5	4	23	9	10	4	65
PH25	1.65	1.412	85.58	54.27	54.35	6	20	5	12	54	49	9	51
PH26	2.10	1.154	54.95	69.23	66.19	33	102	104	68	89	102	83	105
PH27	2.06	1.004	48.74	67.95	63.20	29	94	99	80	83	105	72	83
PH28	1.77	1.297	73.28	58.12	54.94	10	29	6	76	42	43	19	106
PH29	1.92	1.133	59.01	63.25	58.85	21	60	109	81	26	29	85	62
PH30	1.90	1.199	63.11	62.39	60.71	20	55	70	87	31	32	74	52
PH31	1.96	1.069	54.54	64.53	61.25	23	71	110	64	29	72	73	45
PH32	1.87	.801	42.83	61.54	54.99	17	46	66	54	43	25	91	10
PH33	2.06	.894	43.40	67.95	62.23	30	96	88	53	91	104	79	70
PH34	1.62	1.246	76.91	53.42	51.81	4	17	26	70	8	11	24	35
PH35	1.64	1.366	83.29	53.85	52.71	5	19	9	46	20	33	15	36
PH36	1.60	.950	59.38	52.56	47.17	2	14	59	25	7	54	12	6
PH37	1.97	1.032	52.39	64.10	60.09	24	73	52	107	74	77	77	42

Table 13.8 Ranking of Timeframe Occurrence of Emerging Physical Risks

Risk factor **PH24 'Saline water intrusion'** is considered the highest ranked indicator for physical risks, with a mean of 1.45 and severity index of 47.86%, along with an overall ranking of 5th out of 112 emerging risk factors. There is no clear consensus amongst all categories of respondent, as shown in Table 13.8 above. Facility mangers and the public sector ranked the physical risk factor **PH24** at 4th out of 112, and the other role with the private sector ranked 9th and 10th out of 112, respectively. Furthermore, risk mangers ranked this factor 23rd out 112. Nevertheless, the other sectors do not consider this to be their important risk factor list. Generally, the weighted mean through this risk category ranges between 1.45 and 2.40, whilst the severity index ranges from 47.86% to 79.06%.

On the other hand, the least physical risk factor in this cluster is **PH8 'cracking of building fabric'**, which is ranked at 112 out of 112 emerging risk factors, and the facility managers, other professional roles and public sector ranked it as the least risk factor in terms of its occurrence timescale. Moreover, the next lowest ranked physical risks are **PH6 'scour to structures from intense rainfall'** and **PH3 'reduced asset life'**, which overall ranked at 111 and 109, respectively.

13.4.2 Operational Emerging Risks

For the operational risks, the likelihood occurrence timeframe, as presented in Table 13.9 below, shows that 9 out of 18 operational risk factors are ranked amongst the first 30 indicators, namely **OP1 'Increase in energy use', OP2 'Higher energy prices', OP3 'Increasing water costs', OP4 'Water use restriction', OP5 'Higher costs of repair', OP6 'Increased maintenance regimes', OP8 'Increased reliance on mechanical cooling', OP13 'Increase in the cost of waste water discharge'** and **OP18 'Increased slips and falls'**; this includes the first nine risk factors in the list of the first 30 risk factors. This means that half of the operational risks were ranked in the first 30 top indicators, thus indicating that the operational risks are highly expected to occur on the buildings and real estate in near timescale as a result of the effects of CCS. The average weighted mean for these factors varies from 1.13 to 1.69, whilst the severity indices range from 37.18% to 55.56%.

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
OP1	1.27	.641	50.47	41.88	35.76	3	3	3	6	2	6	3	2
OP2	1.13	.409	36.19	37.18	32.75	1	1	1	1	1	1	1	4
OP3	1.26	.497	39.44	41.45	35.59	2	2	2	5	4	2	2	9
OP4	1.57	.818	52.10	51.71	44.49	8	9	11	14	17	5	14	31
OP5	1.40	.634	45.29	46.15	39.82	4	4	10	8	3	12	5	7
OP6	1.55	.735	47.42	50.85	44.42	7	8	22	40	6	67	6	16
OP7	1.81	.744	41.10	59.40	51.52	10	36	34	63	33	19	57	23
OP8	1.69	.782	46.27	55.56	49.73	9	23	24	13	30	13	28	55
OP9	1.81	.918	50.72	59.40	53.63	11	38	47	37	55	24	43	41
OP10	1.84	1.136	61.74	60.68	57.37	13	44	21	60	79	59	42	44
OP11	1.96	1.106	56.43	64.53	60.40	17	72	30	106	81	61	80	46
OP12	2.03	.946	46.60	66.67	60.12	18	86	46	75	95	80	89	59
OP13	1.51	.737	48.81	49.57	42.89	5	6	20	32	5	3	10	14
OP14	1.88	.923	49.10	61.11	54.89	14	49	44	104	40	36	49	81
OP15	1.92	.796	40.05	62.39	55.33	16	59	43	85	64	35	65	67
OP16	1.88	.879	46.76	61.11	54.48	15	50	28	99	48	62	41	66
OP17	1.82	.989	54.34	58.97	54.13	12	42	17	27	78	50	35	57
OP18	1.54	1.160	75.32	50.00	47.01	6	7	33	2	23	44	8	3

Table 13.9 Ranking of Timeframe Occurrence of Emerging Operational Risks

According to the ranking by professional role, there is almost a clear agreement on the most five important risks, with the exception of the risk managers and other professional roles, who added **OP18** and **OP13**, respectively, to their top 5 ranked risks. Furthermore, ranking according to the type of organisation presents that they agreed on the first three important operational risks, which are **OP1, OP2** and **OP3**; the private sector added **OP13** to their top 5 ranked list. However, the public sector and other sectors added the following operational risks to their top 5 ranked list: **OP5**, **OP6** and **OP18**, successively.

On the other hand, the least ranked operational risk is **OP12 'Increased downtime'**, which is ranked at 86 out of 112 in the overall ranking, with an average mean of 2.03 and 66.67% in the severity index. The next two lowest ranked operational risk in terms of their timeframe emergence are **OP11 'Reduced access to facilities'** and **OP15 'Increased costs due to alternative short-term supplies'**, where **OP11** ranked 72 out of 112 emerging risks, whilst **OP15** ranked 59 in terms of their occurrence timescale.

13.4.3 Financial Emerging Risks

In regard to the financial emerging risk factors, only 4 risk factors have being ranked in the first 30 top ranked risks, namely **F9 'Businesses become less competitive', F16 'Increase costs to purchase', F17 'Increased insurance excess'** and **F19 'Additional expense in insuring buildings in flood risk zones'**.

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
F1	1.88	1.000	53.19	62.770563	56.72	7	51	32	101	57	45	68	27
F2	1.88	1.267	67.39	61.97	59.71	8	53	85	48	49	90	37	54
F3	1.94	1.174	60.52	63.68	60.84	11	62	63	88	46	76	70	28
F4	1.79	.998	55.75	58.12	53.87	5	33	42	36	41	30	31	96
F5	1.86	1.167	62.75	61.11	57.82	6	45	79	28	45	103	38	11
F6	1.95	1.180	60.51	64.10	60.69	12	63	106	69	35	89	82	12
F7	2.01	1.070	53.23	66.24	60.77	18	82	82	93	62	92	88	22
F8	2.04	1.129	55.34	67.09	62.94	21	90	94	89	77	41	102	79
F9	1.75	1.205	68.86	57.69	53.77	4	28	48	45	27	23	52	18
F10	2.03	1.051	51.77	66.67	60.96	20	88	107	67	53	88	100	17
F11	2.10	1.059	50.43	69.23	63.88	22	100	69	91	97	48	109	50
F12	2.01	1.057	52.59	66.24	60.88	17	81	108	59	52	37	108	15
F13	1.95	1.123	57.59	64.10	58.82	13	64	86	43	73	81	60	58
F14	1.99	.939	47.19	65.38	58.47	16	80	76	100	56	70	96	19
F15	2.17	.880	40.55	71.37	64.36	23	106	95	92	103	68	111	34
F16	1.73	.898	51.91	56.84	50.12	3	26	51	17	28	21	61	1
F17	1.64	.705	42.99	53.85	45.51	2	18	29	24	18	18	18	39
F18	1.96	1.006	51.33	64.53	57.51	14	66	90	95	37	69	50	101
F19	1.58	.833	52.72	52.14	45.96	1	11	49	11	10	20	11	24
F20	1.97	1.038	52.69	64.96	59.52	15	74	55	20	102	60	86	43
F21	1.88	1.246	66.28	61.97	58.12	9	54	14	65	82	78	48	21
F22	2.01	1.057	52.59	66.24	61.06	19	85	89	82	70	64	87	76
F23	1.91	1.172	61.36	62.82	59.13	10	57	64	42	72	73	53	48

Table 13.10 Ranking of Timeframe Occurrence of Emerging Financial Risks

These factors have a closer mean in the range of 1.58 to 1.75, and the severity indices are within the range of 52.14% to 57.69%. Factor **F19** seems to be the most significant financial risk factor, and has an overall rank of 11th out of 112 emerging risk factors in terms of their emergence timescale.

There is a clear difference amongst the respondents in terms of the most important five risk factors concerning their occurrence timescale on buildings and real estate. Additionally, both risk managers and other practitioners ranked the factor **F19** as 11th and 10th on their top 5 ranked emerging financial risks; the facility managers excluded this from their top 5 ranked list. Also, ranking by the type of organisation, both private and public sectors ranked factor **F19** as 20th and 11th, respectively; other sectors do not consider these in their top 5 ranked list, as presented in Table 13.10. On the other hand, however, the lowest important financial risk factor in terms of occurrence timeframe is **F15 'Affordability of property rent/development'**, which is ranked 106 out of 112 risks emerging from CCS; this came at the bottom list of concern by the public sector. Moreover, the next two lowest important financial risk factors are **F11 'Negative property valuation due to structural damage'** and **F8 'Loss of income from properties'**, which were observed in the overall ranking at 100 and 90 out of the total identified emerging risks, respectively.

13.4.4 Occupant Dissatisfaction Emerging Risks

For occupant dissatisfaction risks, only two risks ranked in the first 30 top ranked amongst these 6 risks, namely **O1 'Thermal discomfort**' and **O2 'Loss of productivity'** with the mean of 1.57 and 1.61, respectively, along with the severity indices of 51.71% and 52.21. The **O1** was considered the highest ranked risk factor in the category, at an overall 10 out of 112. There was an obvious consensus amongst all categories of respondent, as shown in Table 13.11, in terms of their top 5 ranked risk factors of this emerging risks cluster.

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
O1	1.57	.802	51.08	51.71	44.36	1	10	8	33	14	16	22	5
O2	1.61	.891	55.34	52.99	48.21	2	15	36	3	24	46	16	8
O3	1.81	.918	50.72	59.40	52.50	3	37	73	21	36	71	34	26
O4	2.25	.948	42.13	73.93	68.55	6	110	105	102	105	112	106	71
O5	2.04	1.094	53.63	67.09	63.53	5	89	53	98	86	108	78	29
O6	1.96	1.117	56.99	64.53	60.41	4	69	75	97	39	85	58	64

Table 13.11 Ranking of Timeframe Occurrence of Emerging Occupants Dissatisfaction Risks

Conversely, the lowest ranked risk factor in this cluster is **O4 'Usability of buildings become impaired'**, which is ranked at an overall ranking of 110 out of 112 emerging risk factors. It is observed that all professional roles held the same opinion about **O4** in terms of its occurrence timescale, along with the public sector; the private sector, on the other hand, recognised it as being the latest risk emerging from CCS.

13.4.5 Liability and Responsibility Emerging Risks

Regarding the liability and responsibility risk factors, only one of the 6 risk factors ranked in the first 30 top ranked, namely **LR1 'Increase of recourse action against professional advisors'**, which has a weighted mean of 1.73 and severity index of 56.84% along with an overall rating of 25 out of 112. Generally, facility managers and other professionals ranked it as 41st and 44th, respectively, whilst the risk managers considered it 7th out of 112. The public sector ranked it as 13th out of 112; the private and other sectors rated it in the late ranking, as 82nd and 56th, successively. It can be seen from Table 13.12 bellow that risk managers and other sectors held the same view on the most 5 important risks associated with the likely occurrence time of liability and responsibility, as well as the public sector and other practitioners.

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
LR1	1.73	1.120	64.74	56.84	53.62	1	25	41	7	44	82	13	56
LR2	2.01	1.106	55.02	66.24	61.58	3	83	80	79	71	74	69	100
LR3	1.96	1.141	58.21	64.53	59.48	2	70	68	10	98	97	44	74
LR4	2.05	.985	48.05	67.52	62.29	4	91	97	4	109	75	92	73
LR5	2.16	1.052	48.70	70.94	65.27	6	105	83	44	111	107	98	97
LR6	2.16	1.027	47.55	70.94	64.43	5	104	74	57	110	109	93	85

Table 13.12 Ranking of Timeframe Occurrence of Emerging Liability & Responsibility Risks

On the other hand, the lowest ranked risk factor in this category is **LR5 'increasing decommissioning liabilities'**, which ranked 105 out of 112; the other professional roles ranked it 111 whilst the risk managers ranked it 44 out of 112 risk factors. The next lowest ranked risk is **LR6 'professionals (advisers, designers, owners, tenant, insurers) will bear the responsibility of mal-adapted new buildings'**, as also ranked by other professionals at 110 and private organisations at 109 out of 112.

13.4.6 Reputational Emerging Risks

In terms of reputational risks, only two risk factors of the 15 risk factors ranked in the first 30 top ranked**: R13 'increased carbon emissions'** and **R14 'increased level of staff stress'**, with closer weighted mean and an overall ranked as 12th and 27th, respectively, out of 112. The average weighted mean in this risk category varies from 1.60 to 2.19; the severity indices range from 52.56% to 72.22%. According to Table 13.13, there is no clear consensus amongst all categories of respondent in terms of their top 5 ranked list. However, according to their top 5 ranked list all agreed on the **R3 'negative impact on corporate social responsibility'** that ranked as 4th within the group and 34th as an overall ranking.

On the other hand, the lowest ranked risk in this cluster in terms of their occurrence timescale are **R9 'higher liabilities risks'**, **R8 'higher legal risks'** and **R7 'higher economic risks'**; they ranked at an overall ranking of 108, 103 and 98, respectively.

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
R1	2.06	.991	48.11	67.95	60.79	12	93	16	105	104	39	104	91
R2	2.03	1.000	49.26	66.67	59.54	11	87	78	84	76	58	97	77
R3	1.79	1.139	63.63	58.97	55.17	4	34	19	22	63	14	47	47
R4	1.90	1.059	55.74	62.39	57.18	5	56	62	31	68	57	63	33
R5	1.92	1.167	60.78	63.25	59.55	7	61	25	52	87	28	64	102
R6	1.95	1.134	58.15	64.10	60.07	8	65	84	34	75	34	81	88
R7	2.08	.970	46.63	68.38	61.69	13	98	37	74	107	79	101	49
R8	2.13	.965	45.31	70.09	64.12	14	103	72	96	101	99	99	90
R9	2.19	.918	41.92	72.22	65.37	15	108	81	94	106	94	103	110
R10	1.96	1.106	56.43	64.53	60.42	9	68	60	26	93	93	56	63
R11	1.91	1.090	57.07	62.82	57.06	6	58	58	58	66	40	76	53
R12	1.78	.995	55.90	58.55	53.05	3	31	40	18	51	63	26	78
R13	1.60	.831	51.94	52.56	44.96	1	12	15	39	13	38	7	38
R14	1.74	.923	53.97	57.26	51.21	2	27	50	19	34	47	25	61
R15	2.01	.939	46.72	66.24	59.94	10	84	92	83	67	83	75	75

Table 13.13 Ranking of Timeframe Occurrence of Emerging Reputational Risks

13.4.7 Regulatory Emerging Risks

The regulation risks detail only one risk factor—**RE7 'uncertainty of pending legislation on climate change'**—which is ranked in the first 30, ranked as 13th out of 112. The risk factor **RE7** has a mean of 1.60 and severity index of 52.56%. Generally, the weighted mean within this category varies from 1.06 to 2.08 with a severity indices of 52.56% to 62.61%. In addition, as shown in Table 13.14, there is no agreement amongst professionals in terms of the first 5 ranked list; however, the private sector and other sectors hold the same view in terms of the occurrence timescale of the regulation risks within buildings and real estate. Moreover, risk managers and the public sector have the same list of top 5 ranked items in terms of regulation risks.

Importantly, the latest ranked risk factor in this group is **RE4 'stringent regulation in relation to windstorms stress'**, which ranked 97 out of 112 in the overall ranking, as observed in the bottom (111) ranking by the private sector.

R.F Code	All data							Ranking based on role in organisation			Ranking based on type of organisation		
	Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
RE1	1.97	.888	45.10	64.96	56.84	4	76	87	61	61	55	71	82
RE2	1.82	.884	48.57	59.83	51.78	2	43	103	29	22	52	33	68
RE3	2.06	.864	41.94	67.95	59.80	6	95	93	73	84	66	95	89
RE4	2.08	1.073	51.59	68.38	62.61	7	97	56	50	108	111	59	87
RE5	1.88	.778	41.38	61.97	54.14	3	52	61	35	69	53	45	69
RE6	1.99	.769	38.64	65.38	57.36	5	78	77	62	80	51	84	84
RE7	1.60	.799	49.94	52.56	46.43	1	13	39	15	11	7	17	32

Table 13.14 Ranking of Timeframe Occurrence of Emerging Regulatory Risks

13.5 Summary of the Findings from the Rating and Ranking

The results of the rating and ranking have been presented in the former sections of this chapter. Table 13.15 presents the 30 most potential risks emerging from climate change, as extracted based on the overall ranking. The 30 extracted emerging risks are considered the most significant risk factors amongst 112 indicators in this study. From a statistical average weighted mean of each indicator, it can be stated that all mean values carry values of less than 3 (under the neutral point), thus indicating that all of selected indicators could be considered significant emerging risks arising from climate change scenarios on buildings and real estate.

Correspondingly, in relation to the occurrence timeframe of these emerging risks, Table 13.16 illustrates the 30 most important risk factors based on their likelihood of occurrence. Based on the statistical average weighted mean of each risk, it can be concluded that all mean values carry values ranging from 1.13 to 1.78 (where 1= 0–5 years and 2= 5–10 years); this indicates that all of the selected indicators are highly expected to arise in a short period. In addition, by comparing the two tables (13.15 and 13.16), it can be observed that there is clear agreement on **OP2, OP3, OP1** and **OP5**, all of which are in the top list concerning their occurrence likelihood and emergence timescale. Generally, approximately 56% (17 out of 30) of the top ranked factors are agreed upon between respondents, as highlighted in green in Table 13.15; approximately 43% (13 out of 30) are disagreed upon amongst the respondents, as highlighted in red in Table 13.16.

R.F Code	Risk factor	All data							Ranking based on role in organisation			Ranking based on type of organisation		
		Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
OP2	Higher energy prices	1.22	.474	38.85	24.36	14.66	1	1	1	1	1	1	1	1
OP3	Increasing water costs	1.29	.537	41.63	25.90	17.44	2	2	2	2	2	2	2	4
OP1	Increase in energy use	1.62	.841	51.91	32.31	25.16	3	3	3	3	3	7	3	5
OP5	Higher costs of repair	1.67	.715	42.81	33.33	27.97	4	4	5	7	4	6	4	11
OP13	Increase in the cost of waste water discharge	1.68	.637	37.92	33.08	29.40	5	5	4	6	7	4	5	28
OP6	Increased maintenance regimes	1.77	.788	44.52	35.38	31.27	6	6	7	9	6	15	6	7
F17	Increased insurance excess	1.79	.762	42.57	35.90	30.45	1	7	10	10	8	5	7	15
RE7	Uncertainty of pending legislation on climate change	1.82	.802	44.07	36.41	42.33	1	8	14	14	5	8	8	13
O1	Thermal discomfort	1.94	.958	49.38	38.72	35.09	1	9	11	22	11	18	11	6
OP8	Increased reliance on mechanical cooling	1.95	.881	45.18	38.97	35.93	7	10	8	4	22	9	10	24
PH10	Increased capital expenditures	1.95	.866	44.41	38.97	37.45	1	11	9	12	17	16	14	8
RE5	Strict limits on greenhouse gas emissions	1.96	.844	43.06	39.23	37.39	2	12	13	16	12	17	13	10
F19	Additional expense in insuring buildings in flood risk zones	1.96	1.062	54.18	39.23	36.93	2	13	15	15	14	3	26	2
PH23	Increase in the cost of materials supplies	1.97	.967	49.09	39.49	39.12	2	14	6	39	18	10	17	14
RE6	Mandatory climate change risk-appropriate building regulation	2.01	.764	38.01	40.26	39.09	3	15	19	33	9	11	19	12
F16	Increase costs to purchase	2.03	.953	46.95	40.51	38.66	3	16	12	40	15	14	9	50
PH17	Surface water flooding	2.03	1.044	51.43	40.51	37.78	3	17	24	5	19	25	18	3
PH9	Potential need for retrofitting mechanical ventilation	2.06	.873	42.38	41.28	42.31	4	18	16	23	16	24	16	16
R13	Increased carbon emissions	2.06	.998	48.45	41.28	39.98	1	19	21	38	10	38	12	18
OP4	Water use restriction	2.06	1.011	49.08	41.28	39.47	8	20	28	17	13	12	21	9
PH33	Erosion of historic building fabric	2.15	.839	39.02	43.08	43.63	5	21	23	8	28	55	15	29
OP7	Electricity brownouts and blackouts	2.17	.813	37.47	43.33	44.75	9	22	18	29	21	13	25	23
OP15	Increased costs due to alternative short-term supplies	2.26	.859	38.01	45.13	48.03	10	23	44	42	20	20	24	39
RE1	Stringent regulation in relation to water stress	2.27	.878	38.68	45.38	48.38	4	24	39	30	24	37	27	27
R9	Higher liabilities risks	2.28	.737	32.32	45.64	48.70	2	25	17	49	33	47	22	38
RE2	Stringent regulation in relation to flood stress	2.28	.992	43.51	45.64	47.37	5	26	52	28	25	34	31	20
O2	Loss of productivity	2.32	1.063	45.82	46.41	48.50	2	27	54	48	23	45	34	19
OP16	Interruption of supply chain	2.33	.878	37.68	46.67	49.94	11	28	53	43	27	26	43	30
R14	Increased level of staff stress	2.35	.951	40.47	46.92	50.26	3	29	30	51	31	49	20	88
PH32	Increase of damp, condensation and mould problems in buildings	2.35	.895	38.06	46.92	48.45	6	30	27	27	47	32	40	22

Table 13.15 The 30 Most Important Emerging Risks Based on their Likelihood Occurrence

R.F Code	Risk factor	All data							Ranking based on role in organisation			Ranking based on type of organisation		
		Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Category Ranking	Overall Ranking	Facility manager	Risk manager	Other	Private	Public	Other
OP2	Higher energy prices	1.13	.409	36.19	37.18	32.75	1	1	1	1	1	1	1	4
OP3	Increasing water costs	1.26	.497	39.44	41.45	35.59	2	2	2	5	4	2	2	9
OP1	Increase in energy use	1.27	.641	50.47	41.88	35.76	3	3	3	6	2	6	3	2
OP5	Higher costs of repair	1.40	.634	45.29	46.15	39.82	4	4	10	8	3	12	5	7
PH24	Saline water intrusion	1.45	1.372	94.62	47.86	47.53	1	5	4	23	9	10	4	65
OP18	Increased slips and falls	1.54	1.160	75.32	50.00	47.01	6	6	33	2	23	44	8	3
OP6	Increased maintenance regimes	1.55	.735	47.42	50.85	44.42	7	7	22	40	6	67	6	16
OP4	Water use restriction	1.57	.818	52.10	51.71	44.49	8	8	11	14	17	5	14	31
O1	Thermal discomfort	1.57	.802	51.08	51.71	44.36	1	9	8	33	14	16	22	5
F19	Additional expense in insuring buildings in flood risk zones	1.58	.833	52.72	52.14	45.96	1	10	49	11	10	20	11	24
R13	Increased carbon emissions	1.60	.831	51.94	52.56	44.96	1	11	15	39	13	38	7	38
RE7	Uncertainty of pending legislation on climate change	1.60	.799	49.94	52.56	46.43	1	12	39	15	11	7	17	32
PH36	Insufficient roof drainage in storms	1.60	.950	59.38	52.56	47.17	2	13	59	25	7	54	12	6
O2	Loss of productivity	1.61	.891	55.34	52.99	48.21	2	14	36	3	24	46	16	8
PH17	Surface water flooding	1.61	.830	51.55	52.99	46.25	3	15	45	16	12	8	21	25
PH34	Lightning strike damage to buildings during storms	1.62	1.246	76.91	53.42	51.81	4	16	26	70	8	11	24	35
F17	Increased insurance excess	1.64	.705	42.99	53.85	45.51	2	17	29	24	18	18	18	39
PH35	Slope instability	1.64	1.366	83.29	53.85	52.71	5	18	9	46	20	33	15	36
PH25	Corrosive saline atmospheric exposure	1.65	1.412	85.58	54.27	54.35	6	19	5	12	54	49	9	51
PH18	Groundwater water flooding (from rising groundwater)	1.65	.997	60.42	54.27	50.76	7	20	57	9	15	9	36	13
PH2	Potential for increased odour problems	1.68	1.400	83.33	55.13	52.43	8	21	7	77	21	42	20	30
OP8	Increased reliance on mechanical cooling	1.69	.782	46.27	55.56	49.73	9	22	24	13	30	13	28	55
PH23	Increase in the cost of materials supplies	1.69	.892	52.78	55.56	49.98	9	23	23	78	16	15	30	40
LR1	Increase of recourse action against professional advisors	1.73	1.120	64.74	56.84	53.62	1	24	41	7	44	82	13	56
F16	Increase costs to purchase	1.73	.898	51.91	56.84	50.12	3	25	51	17	28	21	61	1
R14	Increased level of staff stress	1.74	.923	53.97	57.26	51.21	2	26	50	19	34	47	25	61
F9	Businesses become less competitive	1.75	1.205	68.86	57.69	53.77	4	27	48	45	27	23	52	18
PH28	Extreme exposure of building shell to dust	1.77	1.297	73.28	58.12	54.94	10	28	6	76	42	43	19	106
PH20	Water ingress to roofs	1.77	.985	55.65	58.12	53.21	11	29	96	41	19	31	29	93
PH13	Damage to building foundation due to subsidence and heave movement	1.78	1.363	76.57	58.55	57.80	12	30	13	47	50	27	27	111

Table 13.16 The 30 Most Important Emerging Risks Based on their Occurrence Timeframe

13.6 Results for Kendal's Concordance Analysis

In this research project, Kendall's coefficients concordance is applied in an effort to examine agreement between the respondents to the survey on the ranking of emerging risk factors of CCS. From both tables below (Table 13.17 and Table 13.18), the respondents showed highly significant concordance (p-value<.001) concerning the risks of interest. Hence, this indicates that the null hypothesis (there is no agreement between respondents) has to be accepted. Furthermore, the alternative hypothesis—suggesting that there is a significant agreement amongst all categories of respondents—is rejected. The statistical results of the calculated coefficient of variation indicate that there is variation in regard to practitioner responses. According to the results shown in Kendall's coefficients concordance analysis, the data are reliable as the significance value is less than 0.05; thus, there is disagreement between the groups of respondent.

Risks Category	Kendall's W	Chi-square	p-value
Physical risks	.239	671.426	<.001
Operational risks	.378	495.123	<.001
Financial risks	.191	323.576	<.001
Occupants dissatisfaction risks	.179	69.969	<.001
Liability & Responsibility risks	.063	24.507	<.001
Reputational risks	.092	100.839	<.001
Regulation risks	.233	108.989	<.001

Table 13.17 Kendall's Concordance Analysis for Likelihood Occurrence of CCR Factors

Risks Category	Kendall's W	Chi-square	p-value
Physical risks	.05	135.58	<.001
Operational risks	.132	169.99	<.001
Financial risks	.040	66.237	<.001
Occupants dissatisfaction risks	.159	61.237	<.001
Liability & Responsibility risks	.042	16.346	<.001
Reputational risks	.052	56.117	<.001
Regulation risks	.069	32.013	<.001

Table 13.18 Kendall's W Test for Timeframe Occurrence of CCR Factors

13.7 Average Rating for the Climate Change Risk Management Factors

The CCRM comprises 24 risk management factors, which were extracted from a literature review of risk management associated with risks emerging from CCS on buildings and real estate. The list of risk strategies established were delivered amongst the survey participants in order to elicit data relating to the effectiveness of CCRM strategies. Respondents were asked to rate the effectiveness of these factors in response to the emerging risks of climate change using a Likert scale of 1–5 as (1= very effective; 2= effective; 3= neutral; 4= ineffective and 5= very ineffective) in order to provide a general idea of the effectiveness and importance of the risk management strategies extracted, related to the risks emerging from CCS on the building sector.

R.M Code	CCRM Factors	Mean	S.D	Coefficient of variation	Severity index	Mean Rank Kendall	Overall Ranking
RM1	Disruption planning	2.22	.658	29.65	44.36	62.74	19
RM2	Balancing resources	2.33	.715	30.63	46.67	66.31	21
RM3	Stand-by-preparation	2.21	.691	31.32	44.10	61.32	17
RM4	Maintenance planning	1.90	.749	39.47	37.95	46.35	3
RM5	Operations planning	1.97	.683	34.61	39.49	51.00	7
RM6	Resource planning	2.10	.713	33.93	42.05	55.62	14
RM7	Maintenance scheduling	1.91	.793	41.49	38.21	47.40	4
RM8	Adaptation planning	2.14	.849	39.63	42.82	57.17	15
RM9	Property portfolio climate change risk management	2.21	.827	37.52	44.10	60.36	18
RM10	Financial stress emergency plans	2.49	.879	35.34	49.74	70.58	24
RM11	Development of new compliance infrastructure	2.26	.746	33.07	45.13	62.04	20
RM12	Mitigation plans for disruption to business processes	2.04	.860	42.16	40.77	53.50	11
RM13	Plans to deal with changes in market demand	2.36	.868	36.78	47.18	66.24	22
RM14	Mitigation plans for disruption to supply chain	2.37	.839	35.38	47.44	67.60	23
RM15	Availability of resources	2.19	.790	36.06	43.85	59.55	16
RM16	FM strategies to improve properties to reduce emissions	1.96	.860	43.82	39.23	48.82	6
RM17	Plans to improve equipment to reduce emissions	1.75	.824	46.95	35.12	38.34	2
RM18	Plans to manage water footprint	1.98	.781	39.31	39.74	49.99	8
RM19	Plans to use adaptation technology	2.05	.771	37.60	41.02	53.47	12
RM20	Strategy to improve energy efficiency	1.65	.752	45.53	33.07	35.05	1
RM21	Increasing use of renewable energy	1.91	.855	44.79	38.20	46.14	5
RM22	Plans to generate renewable energy on site	2.06	.944	45.75	41.28	52.23	13
RM23	Water management mitigation plans	2.02	.805	39.76	40.51	50.75	10
RM24	Waste management plans	1.98	.904	45.51	39.74	49.23	9

Table 13.19 Ranking and Rating of Climate Change Risk Management Factors

Moreover, this will be illustrative, without going into intensive detail, such as in terms of the interpretation and magnitude value of the effectiveness. Table 13.19 above presents all CCRM factors, where the average weighted mean varies from 1.65 to 2.49, which is less than a neutral score (3). In addition, the severity indices range changes within 33.07% to 49.74%. The list of the 10 most effective climate change risks management factors were highlighted in the Table 13.19, namely **H20 'Strategy to improve energy efficiency', H17 'plans to improve equipment to reduce emissions', H4 'maintenance planning', H7 'maintenance scheduling', H21 'increasing use of renewable energy', H16 'FM strategies to improve properties to reduce emissions', H5 'operations planning', H18 'plans to manage water footprint', H24 'waste management plans'** and **H23 'water management mitigation plans'**.

R.M Code	Ranking based on role in organisation									Ranking based on type of organisation									Overall Ranking
	Facility manager			Risk manager			Other			Private			Public			Other			
	Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank	
RM1	2.55	0.67	19	1.93	0.70	16	2.15	0.58	18	2.24	0.56	13	2.22	0.71	20	2.18	0.60	13	19
RM2	2.73	0.63	23	2.13	0.83	20	2.20	0.65	20	2.29	0.77	15	2.30	0.71	22	2.55	0.69	22	21
RM3	2.32	0.84	11	1.93	0.59	15	2.25	0.63	22	2.18	0.64	8	2.18	0.72	18	2.36	0.67	20	17
RM4	2.09	0.81	4	2.00	0.93	17	1.75	0.63	2	2.00	0.61	4	1.86	0.81	7	1.91	0.70	2	3
RM5	2.27	0.70	8	1.87	0.74	13	1.85	0.62	5	2.24	0.44	12	1.92	0.75	10	1.82	0.60	1	7
RM6	2.50	0.67	16	2.20	0.68	21	1.85	0.66	6	2.29	0.59	16	2.06	0.77	14	2.00	0.63	5	14
RM7	2.18	0.80	5	1.80	0.94	12	1.80	0.72	4	2.06	0.83	5	1.84	0.79	6	2.00	0.77	6	4
RM8	2.55	0.80	18	1.93	0.70	14	2.00	0.88	14	2.35	0.79	18	2.10	0.81	16	2.00	1.10	10	15
RM9	2.55	0.67	17	1.80	0.86	9	2.15	0.83	19	2.24	0.75	11	2.20	0.83	19	2.18	0.98	16	18
RM10	2.82	0.85	24	2.33	0.72	24	2.38	0.93	24	2.53	0.72	22	2.52	0.91	24	2.27	1.01	17	24
RM11	2.55	0.80	20	2.07	0.59	19	2.15	0.74	17	2.47	0.72	21	2.24	0.74	21	2.00	0.77	8	20
RM12	2.41	0.96	15	1.73	0.70	6	1.98	0.80	12	2.06	0.90	6	2.04	0.88	13	2.00	0.77	7	11
RM13	2.64	0.79	21	2.27	1.03	23	2.23	0.83	21	2.65	0.61	23	2.16	0.84	17	2.82	1.08	24	22
RM14	2.68	0.78	22	2.27	0.88	22	2.25	0.84	23	2.29	0.77	17	2.36	0.88	23	2.55	0.82	23	23
RM15	2.41	0.80	14	2.07	0.59	18	2.13	0.85	16	2.35	0.79	19	2.08	0.83	15	2.45	0.52	21	16
RM16	2.27	1.08	9	1.73	0.70	8	1.88	0.76	8	1.88	0.86	3	1.90	0.89	8	2.36	0.67	19	6
RM17	1.95	0.90	2	1.47	0.64	1	1.75	0.84	3	1.76	0.75	2	1.64	0.72	2	2.27	1.19	18	2
RM18	2.36	1.00	12	1.73	0.70	7	1.88	0.61	7	2.18	0.73	9	1.90	0.79	9	2.09	0.83	11	8
RM19	2.32	0.84	10	1.73	0.59	5	2.00	0.75	13	2.12	0.86	7	2.00	0.76	12	2.18	0.75	14	12
RM20	1.82	0.96	1	1.53	0.52	2	1.60	0.71	1	1.71	0.85	1	1.56	0.64	1	2.00	1.00	9	1
RM21	2.00	0.98	3	1.67	0.62	4	1.95	0.88	11	2.18	0.88	10	1.82	0.85	3	1.91	0.83	3	5
RM22	2.23	1.15	7	1.67	0.62	3	2.10	0.90	15	2.65	1.17	24	1.84	0.77	5	2.18	0.98	15	13
RM23	2.36	1.00	13	1.80	0.68	11	1.93	0.69	9	2.24	0.90	14	1.98	0.77	11	1.91	0.83	4	10
RM24	2.23	1.02	6	1.80	0.94	10	1.93	0.83	10	2.35	0.86	20	1.84	0.87	4	2.09	1.04	12	9

Table 13.20 Average Rating for the Climate Change Risk Management Factors

From the statistical average weighted mean of each indicator, it can be stated that all mean values carry values under the neutral score (3); this leads to the indication that all CCRM could be considered a significant effective risk management strategy that assists buildings and real estate in avoiding or coping with the risks emerging from CCP. In addition, the overall results from the ranking illustrate that, amongst the 10 most effective CCRM factors, RM20 is the most important risk management factor. This was ranked as the most effective risk management factor amongst the private sector, public sector, facility managers and other professionals, as shown in Table 13.20. Risk managers and other sectors ranked this as 2nd and 9th, respectively.

According to the results obtained from the respondents (detailed in Table 13.20), **RM20** and **RM17** are recognised as the two most effective risk management tools amongst all categories of respondent, except the other sector, which held the view that **RM4** and **RM5** are the most effective factors. However, risk managers perceived risk management strategy (**RM20**) as less important than **RM17**; the other professional practitioners added **RM4** as the second effective risk management strategy related to the emerging risks of climate change. It can be seen that there is no clear consensus regarding the top 10 of most effective risk management indicators throughout all professional roles, as well concerning all type of sector and organisation. Such a lack of consensus in ranking the order of most effective CCRM factors refers to the potential difference in responsibilities and roles within and across buildings and real estate in terms of managing and controlling the risks arising from CCS.

On the other hand, however, the lowest ranked CCRM factors in terms of their effectiveness level are **RM10 'financial stress emergency plans', RM14 'mitigation plans for disruption to supply chain'** and **RM13 'plans to deal with changes in market demand'**, where **RM10** was ranked as least effective CCRM strategy by all groups of respondent except the private sector, which ranked 22 out of 24 CCRM factors.

13.8 Summary of this Chapter

This chapter of the research project presented and described the rating and ranking results based on the ranking techniques, including weighted mean, standard deviation and severity index in an effort to indicate the most important emerging risks. The ranking and rating results are illustrated in Table 13.1–Table 13.7 for the likelihood of occurrence of emerging risks of climate change; Table 13.8–Table 13.14 details the timeframe likelihood occurrence of risks emerging from climate change. The selected top 30 emerging risks are presented in Table 13.15 and Table 13.16, confirming that all selected emerging risks score under the neutral point; this claims that these emerging risks potentially occur on buildings and real estate within a short period of time.

The last part of this chapter centred on ranking the climate change risk management factors, as presented in Table 13.19 and Table 13.20. Moreover, all risk management factors have a score of less than 3 (neutral), meaning that all climate change rick management strategies can be considered effective factors in terms of mitigating and adapting buildings and real estate with emerging risks of climate change. In addition, these tables show the area of consensus, as well as disagreements in the rating and ranking of these factors amongst all categories of respondent. This will be illustrated and discussed in detail in the next chapters of this research.

CHAPTER 14: HYPOTHESIS TEST

14.1 Introduction

The previous chapters described and ranked the survey results. It was clear from the calculation of the means, standard deviations and coefficient of variation that there was a quite close response amongst respondents based on both the type of organisation and the professional role. Accordingly, it seems that there is not much significance in terms of the differences between respondent groups; however, the aim of this chapter is to test the research hypothesis in an effort to confirm the statistical differences in group responses through the use of the ANOVA method in SPSS software. The ANOVA analysis will centre on all risks emerging from climate change, related to their likelihood occurrence based on the type of organisation and the professional role in organisations. Moreover, the description in this section is limited to the important emerging risks of each cluster in the top 30 ranked emerging risks. Notably, the full results can be seen in Appendix D. Additionally, in regard to the timeframe of the emerging risks, the ANOVA analysis will be limited to the top 30 risks ranked by respondents in an effort to achieve manageable discussion. The following sections in this chapter will illustrate the results of the ANOVA method test.

14.2 ANOVAs Rating of Likelihood Occurrence Based on Type of Organisation

According to all types of organisation, the apparent difference in the resulting means is not strong evidence for any real differences between them. As a result, it was important to examine the research hypothesis using one-way ANOVA testing in order to establish whether or not there is a significant difference between the three organisations (public, private and others). The main hypotheses are as follows:

Ha_0 ($p > 0.05$): there is no significant difference between respondents in terms of the rating for the likelihood of the occurrence of risks emerging from climate change.

Ha_{01} ($p < 0.05$): there is a significant difference between respondents in terms of the rating for the likelihood of the occurrence of risks emerging from climate change.

14.2.1 Physical Emerging Risks

Using the ANOVA test at a 0.05 level of significance, the interest is to test the following hypotheses:

Ha_0 ($p > 0.05$): there is no significant difference between respondents (types of organisation) in terms of the rating for the likelihood of the occurrence of risks emerging from climate change scenarios.

Ha_1 ($p < 0.05$): there is a significant difference between respondents (types of organisation) in terms of the rating for the likelihood of the occurrence of risks emerging from climate change scenarios.

Table 14.1 shows the results of the ANOVA analysis of the physical risk factors for the three organisations. The results confirm that there is no significant difference across each physical effect risk between the three organisations since p-value > 0.05. Hence, the null hypothesis Ha_0 is accepted, meaning that the three organisations shared the same opinion on the likelihood of occurrence of emerging physical risk; therefore, there is no significant difference between them in terms of the likelihood of occurrence of physical risks emerging from climate change.

		Sum of Squares	df	Mean Square	F	Sig.
PH9	Between Groups	.792	2	.396	.513	.601
	Within Groups	57.888	75	.772		
	Total	58.679	77			
PH10	Between Groups	.633	2	.317	.415	.662
	Within Groups	57.162	75	.762		
	Total	57.795	77			
PH17	Between Groups	3.343	2	1.671	1.555	.218
	Within Groups	80.606	75	1.075		
	Total	83.949	77			
PH23	Between Groups	.628	2	.314	.330	.720
	Within Groups	71.321	75	.951		
	Total	71.949	77			
PH32	Between Groups	.862	2	.431	.532	.590
	Within Groups	60.791	75	.811		
	Total	61.654	77			
PH33	Between Groups	3.302	2	1.651	2.435	.094
	Within Groups	50.852	75	.678		
	Total	54.154	77			

Table 14.1 ANOVA Analysis (F-value and significant value) of Physical Risks Based on Type of Organisation

14.2.2 Operational Emerging Risks

The ranking of the operational emerging risks detailed in the previous chapter show that there are slight differences between organisations in terms of the likelihood occurrence of this risk category; therefore, the ANOVA test has been applied at a 0.05 level of significance in order to test the research hypothesis. The results given in Table 14.2 confirm that the effect of operational risks was the same for the three organisations, except in the case of one of the operational emerging risks, which is **OP13**, namely **increase in the cost of waste water discharge**. In other words, **OP13** was a significant difference between the three organisations since F=3.45 with p-value=0.037. Hence, Ha_1 hypothesis is only accepted for this operational risk. In this case, the Post Hoc Multiple Comparison Test will be adopted in order to determine the difference in specific means between the organisations. The Tukey test, as one of the Post Hoc Multiple Comparison Tests, was preferred as the sample size is uneven. From the completion of the Tukey test, it was found that there was no difference between the private and public organisations, and no significant difference between the public and other organisations, as shown in Table 14.3. Significant difference (p-value=.03) was found between the private and other organisations, where the private organisation showed higher concern with the effect of the **OP13** than the other types of organisation.

		Sum of Squares	df	Mean Square	F	Sig.
OP1	Between Groups	.205	2	.102	.142	.868
	Within Groups	54.257	75	.723		
	Total	54.462	77			
OP2	Between Groups	.228	2	.114	.502	.607
	Within Groups	17.067	75	.228		
	Total	17.295	77			
OP3	Between Groups	.940	2	.470	1.657	.198
	Within Groups	21.278	75	.284		
	Total	22.218	77			
OP4	Between Groups	2.733	2	1.366	1.349	.266
	Within Groups	75.947	75	1.013		
	Total	78.679	77			
OP5	Between Groups	.388	2	.194	.373	.690
	Within Groups	38.946	75	.519		
	Total	39.333	77			
OP6	Between Groups	1.164	2	.582	.935	.397
	Within Groups	46.682	75	.622		
	Total	47.846	77			
OP7	Between Groups	1.363	2	.682	1.033	.361
	Within Groups	49.470	75	.660		
	Total	50.833	77			
OP8	Between Groups	.495	2	.248	.313	.732
	Within Groups	59.300	75	.791		
	Total	59.795	77			

OP13	Between Groups	2.637	2	1.318	3.454	.037
	Within Groups	28.246	74	.382		
	Total	30.883	76			
OP15	Between Groups	.236	2	.118	.156	.856
	Within Groups	56.636	75	.755		
	Total	56.872	77			
OP16	Between Groups	.638	2	.319	.408	.667
	Within Groups	58.695	75	.783		
	Total	59.333	77			

Table 14.2 ANOVA Analysis (F-value and significant value) of Operational Risks Based on Type of Organisation

OP13				
(I) Type of organisation	**(J)** Type of organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Private	Public	-.182	.174	.548
	Other	-.620*	.239	.030
Public	Private	.182	.174	.548
	Other	-.438	.206	.092
Other	Private	.620*	.239	.030
	Public	.438	.206	.092

*The mean difference is significant at the 0.05 level.

OP13 Increase in the cost of waste water discharge

Table 14.3 Multiple Comparisons Test by Tukey HSD

14.2.3 Financial Emerging Risks

Statistically, the ANOVA test (see Table 14.4) shows that the impact scale of emerging financial risks was the same for three organisations (p-value >0.05, meaning the null hypothesis is accepted. The only significant difference was found for 1 out of 23 financial risk factors; this factor is **F19**, namely **additional expense in insuring buildings in flood risk zones**, where F=6.39 with p-value=0.003. As a result, Ha_1 hypothesis is accepted for the financial emerging risk F19. Using the Tukey test, the only difference was established between the private and public sector (p-value=.005), as highlighted in Table 14.5. Considering the mean difference, private organisations had more concern regarding the effect of **F19 'additional expense in insuring buildings in flood risk zones'** than the public sector.

		Sum of Squares	df	Mean Square	F	Sig.
F16	Between Groups	3.460	2	1.730	1.952	.149
	Within Groups	66.488	75	.887		
	Total	69.949	77			
F17	Between Groups	.479	2	.240	.406	.668
	Within Groups	44.239	75	.590		
	Total	44.718	77			
F19	Between Groups	12.655	2	6.327	6.393	.003
	Within Groups	74.230	75	.990		
	Total	86.885	77			

Table 14.4 ANOVA Analysis (F-value and significant value) of Financial Risks Based on Type of Organisation

F19				
(I) Type of organisation	**(J)** Type of organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Private	Public	-.907*	.279	.005
	Other	-.193	.385	.871
Public	Private	.907*	.279	.005
	Other	.715	.331	.086
Other	Private	.193	.385	.871
	Public	-.715	.331	.086

*The mean difference is significant at the 0.05 level.

F19 Additional expense in insuring buildings in flood risk zones

Table 14.5 Multiple Comparisons Test by Tukey HSD

14.2.4 Occupant Dissatisfaction Emerging Risks

The result of the ANOVA analysis of the most important occupant dissatisfaction emerging risks are illustrated in Table 14.6. Looking at Table 14.6, along with full results detailed in Appendix D, the likely occurrence impact of occupant dissatisfaction risks was the same for the three organisation since the ANOVA test did not show any significant difference (p-value >0.05) for all statements. Therefore, the null hypothesis Ha_0 was accepted for the statements.

		Sum of Squares	df	Mean Square	F	Sig.
O1	Between Groups	1.273	2	.636	.688	.506
	Within Groups	69.407	75	.925		
	Total	70.679	77			
O2	Between Groups	1.350	2	.675	.591	.556
	Within Groups	85.638	75	1.142		
	Total	86.987	77			

Table 14.6 ANOVA Analysis (F-value and significant value) of Occupant dissatisfaction risks based on type of organisation

14.2.5 Liability and Responsibility Risks

The ANOVA method was also used to test the risks emerging concerning liability and responsibility. Statistically, the ANOVA test presented in Appendix D was not found to encompass significant difference (p-value >0.05) between organisations. More specifically, the respondents from the three organisations shared the same view of likelihood of occurrence concerning the impact of liability and responsibility emerging risk. Therefore, the Ha_0 hypothesis is accepted for all statements in this group of emerging risks.

14.2.6 Reputational Emerging Risks

The result of ranking reputational risks in the previous chapters shows that there are some differences between respondents. Consequently, the ANOVA test has been adopted to justify the group responses through testing the research hypotheses.

Based on Table 14.7 below, no significant difference was identified in terms of the likely impact of the majority of statements of emerging reputation risks due to the three organisations. In particular, the respondents from the three organisations shared the view of likely occurrence impact of reputation risks; therefore, the null hypothesis is accepted for all statements except one out of 18; this factor is **'increased level of staff stress'** (**R14**), where the difference was significant since F=3.99 with p-value=0.023. According to Table 14.8, using the Tukey test, the only significant difference was between the public and the other type of organisations and institutions (p-value=.020), where public organisations showed a greater likelihood of occurrence impact than the other types of organisation or institution.

		Sum of Squares	df	Mean Square	F	Sig.
R9	Between Groups	.375	2	.188	.340	.713
	Within Groups	41.419	75	.552		
	Total	41.795	77			
R13	Between Groups	1.817	2	.909	.910	.407
	Within Groups	74.862	75	.998		
	Total	76.679	77			
R14	Between Groups	6.699	2	3.349	3.990	.023
	Within Groups	62.955	75	.839		
	Total	69.654	77			

Table 14.7 ANOVA Analysis (F-value and significant value) of Reputational Risks Based on Type of Organisation

R14				
(I) Type of organisation	**(J)** Type of organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Private	Public	.311	.257	.453
	Other	-.529	.355	.300
Public	Private	-.311	.257	.453
	Other	-.840*	.305	.020
Other	Private	.529	.355	.300
	Public	.840*	.305	.020

*The mean difference is significant at the 0.05 level.

R14 Increased level of staff stress

Table 14.8 Multiple Comparisons Test by Tukey HSD

14.2.7 Regulatory Emerging Risks

The ANOVA test has been also applied in order to test the regulation emerging risks. Table 14.9 below presents the ANOVA test results, without significant differences (p-value>0.05), meaning that there is no significant difference in the likelihood occurrence of all statements of regulation risk according to the three organisations. More specifically, the respondents from the three organisations shared the same view of likelihood of occurrence of the impact of emerging regulation risks; therefore, the null hypothesis Ha_0 is accepted for all emerging risk factors in this category.

		Sum of Squares	df	Mean Square	F	Sig.
RE1	Between Groups	.475	2	.237	.302	.740
	Within Groups	58.871	75	.785		
	Total	59.346	77			
RE2	Between Groups	1.033	2	.516	.518	.598
	Within Groups	74.762	75	.997		
	Total	75.795	77			
RE5	Between Groups	.782	2	.391	.542	.584
	Within Groups	54.103	75	.721		
	Total	54.885	77			
RE6	Between Groups	1.086	2	.543	.928	.400
	Within Groups	43.901	75	.585		
	Total	44.987	77			
RE7	Between Groups	.072	2	.036	.055	.947
	Within Groups	49.415	75	.659		
	Total	49.487	77			

Table 14.9 ANOVA Analysis (F-value and significant value) of Regulatory Risks Based on Type of Organisation

14.3 ANOVAs Rating of Likelihood Occurrence Based on Professional Role

The ANOVA analysis is carried out in this section as based on respondents' professional role in their organisations in order determine the significant difference between all professional roles (facility manager, risk manager and other role). The main hypothesis is as following:

Ha_2 ($p > 0.05$): there is no significant difference between respondents (professional roles in organisations) in terms of the rating for the likelihood of the occurrence of risks emerging from climate change.

Ha_{02} ($p < 0.05$): there is significant difference between respondents (professional roles in organisations) in terms of the rating for the likelihood of the occurrence of risks emerging from climate change.

14.3.1 Physical Emerging Risks

The result ranking based on the role in organisations of the physical risks showed, in previous chapters, that there are some differences between respondents. For this reason, the ANOVA test has been used to justify the group responses through testing the research hypotheses. Based on Table 14.10 below, there was a significant difference between the roles in organisations in terms of 5 out of 37 emerging physical risks. These are **PH8 'Cracking of building fabric'** F=4.529, p-value=.014, **PH12 'Increasing subsidence and heave movement'** F=5.062, p-value=0.009, **PH13 'Damage to building foundation due to subsidence and heave movement'** F=6.516, p-value=.002, **PH14 'Damage to building facades due to subsidence and heave movement'** F=7.543, p-value=.001, and **PH15 'Increasing soil shrinking and swelling'** F=4.631, p-value=.013. Therefore, *Ha_{02}* was accepted for these statements. Due to these significant differences, the Tukey test was applied, as detailed in Table 14.11, where the likelihood occurrence of **PH8** was found to be significantly higher amongst the risk managers than the facility managers as p-value=0.01. Furthermore, in terms of **PH12** risk, the likelihood occurrence of its impact was significantly higher amongst risk managers than facility managers where p-value=0.006. Similarly, the likelihood occurrence impact of **PH13** was significantly higher amongst risk managers than facility managers, as the p-value =.002. In addition, the likelihood occurrence impact of **PH15** was significantly higher amongst the risk managers than facility managers where the p-value =.009. It can be recognised that the significant difference in the likelihood occurrence impact of physical risks was only observed between the facility managers and risk managers, whilst the risk managers showed more concern for the potential emergence of these physical risks. These concerns from risk managers could be owing to their specialisations and duties towards buildings and real estate in dealing with potential risks from CCS.

		Sum of Squares	df	Mean Square	F	Sig.
PH8	Between Groups	8.147	2	4.073	4.529	.014
	Within Groups	66.555	74	.899		
	Total	74.701	76			
PH9	Between Groups	1.493	2	.746	.981	.380
	Within Groups	56.299	74	.761		
	Total	57.792	76			
PH10	Between Groups	.167	2	.083	.115	.891
	Within Groups	53.366	74	.721		
	Total	53.532	76			
PH11	Between Groups	1.635	2	.818	.825	.442
	Within Groups	73.352	74	.991		
	Total	74.987	76			
PH12	Between Groups	8.024	2	4.012	5.062	.009
	Within Groups	58.652	74	.793		
	Total	66.675	76			
PH13	Between Groups	11.073	2	5.537	6.516	.002
	Within Groups	62.875	74	.850		
	Total	73.948	76			
PH14	Between Groups	12.699	2	6.350	7.543	.001
	Within Groups	62.288	74	.842		
	Total	74.987	76			
PH15	Between Groups	7.821	2	3.910	4.631	.013
	Within Groups	62.491	74	.844		
	Total	70.312	76			
PH17	Between Groups	3.290	2	1.645	1.527	.224
	Within Groups	79.697	74	1.077		
	Total	82.987	76			
PH32	Between Groups	.015	2	.007	.009	.991
	Within Groups	61.206	74	.827		
	Total	61.221	76			
PH33	Between Groups	1.504	2	.752	1.131	.328
	Within Groups	49.197	74	.665		
	Total	50.701	76			

Table 14.10 ANOVA Analysis (F-value and significant value) of Physical Risks Based on Role in Organisation

PH8				
(I) role in organisation	**(J)** role in organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Facility manager	Risk manager	.955*	.318	.010
	Other	.355	.252	.342
Risk manager	Facility manager	-.955-*	.318	.010
	Other	-.600-	.287	.099
Other	Facility manager	-.355-	.252	.342
	Risk manager	.600	.287	.099

PH12				
(I) role in organisation	**(J)** role in organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Facility manager	Risk manager	.942*	.298	.006
	Other	.309	.236	.395
Risk manager	Facility manager	-.942-*	.298	.006
	Other	-.633-	.270	.055
Other	Facility manager	-.309-	.236	.395
	Risk manager	.633	.270	.055

PH13				
(I) role in organisation	**(J)** role in organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Facility manager	Risk manager	1.100*	.309	.002
	Other	.325	.245	.384
Risk manager	Facility manager	-1.100-*	.309	.002
	Other	-.775-*	.279	.019
Other	Facility manager	-.325-	.245	.384
	Risk manager	.775*	.279	.019

PH14				
(I) role in organisation	**(J)** role in organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Facility manager	Risk manager	1.188*	.307	.001
	Other	.405	.244	.227
Risk manager	Facility manager	-1.188-*	.307	.001
	Other	-.783-*	.278	.017
Other	Facility manager	-.405-	.244	.227
	Risk manager	.783*	.278	.017

PH15				
(I) role in organisation	**(J)** role in organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Facility manager	Risk manager	.936*	.308	.009
	Other	.386	.244	.259
Risk manager	Facility manager	-.936-*	.308	.009
	Other	-.550-	.278	.125
Other	Facility manager	-.386-	.244	.259
	Risk manager	.550	.278	.125

*The mean difference is significant at the 0.05 level.

PH8 Cracking of building fabric.
PH12 Increasing subsidence and heave movement.
PH13 Damage to building foundation due to subsidence and heave movement.
PH14 Damage to building facades due to subsidence and heave movement.
PH15 Increasing soil shrinking and swelling.

Table 14.11 Multiple Comparisons Test by Tukey HSD

14.3.2 Operational Emerging Risks

The ANOVA analysis results of the emerging operational risks are given in Table 14.12, confirming that the three roles in the organisations hold the same view in terms of the likelihood of the occurrence of the impact of operational risks as the p-value>.05. In particular, the likely occurrence impact of such risks was the same amongst the three groups of professionals; hence, Ha_2 hypothesis was accepted. This also supports the importance of the operational risks, as 11 of the 18 factors were ranked in the top 30 emerging risk factors.

		Sum of Squares	df	Mean Square	F	Sig.
OP1	Between Groups	.150	2	.075	.114	.892
	Within Groups	48.552	74	.656		
	Total	48.701	76			
OP2	Between Groups	.703	2	.351	1.628	.203
	Within Groups	15.973	74	.216		
	Total	16.675	76			
OP3	Between Groups	.617	2	.309	1.083	.344
	Within Groups	21.097	74	.285		
	Total	21.714	76			
OP4	Between Groups	2.569	2	1.285	1.249	.293
	Within Groups	76.106	74	1.028		
	Total	78.675	76			
OP5	Between Groups	.552	2	.276	.614	.544
	Within Groups	33.266	74	.450		
	Total	33.818	76			
OP6	Between Groups	1.224	2	.612	1.089	.342
	Within Groups	41.581	74	.562		
	Total	42.805	76			
OP7	Between Groups	.729	2	.365	.578	.564
	Within Groups	46.699	74	.631		
	Total	47.429	76			
OP8	Between Groups	2.469	2	1.235	1.625	.204
	Within Groups	56.206	74	.760		
	Total	58.675	76			
OP13	Between Groups	.324	2	.162	.388	.680
	Within Groups	30.452	73	.417		
	Total	30.776	75			
OP15	Between Groups	3.672	2	1.836	2.557	.084
	Within Groups	53.133	74	.718		
	Total	56.805	76			
OP16	Between Groups	2.595	2	1.298	1.706	.189
	Within Groups	56.288	74	.761		
	Total	58.883	76			

Table 14.12 ANOVA Analysis (F-value and significant value) of Operational Risks Based on Role in Organisation

14.3.3 Financial Emerging Risks

The ANOVA method was applied in order to test the likelihood of the occurrence of impact of emerging financial risks; the result of the test is presented in Table 14.13, which notably confirms that the effect of financial risks was the same for the three roles in originations as the p-value>.05. Specifically, in this category of emerging risks, the likelihood occurrence impact was found to be the same amongst all three professional roles in organisations. Therefore, the null hypothesis Ha_2 is accepted for all emerging financial risk factors.

		Sum of Squares	df	Mean Square	F	Sig.
F16	Between Groups	2.619	2	1.309	1.439	.244
	Within Groups	67.330	74	.910		
	Total	69.948	76			
F17	Between Groups	.751	2	.376	.633	.534
	Within Groups	43.924	74	.594		
	Total	44.675	76			
F18	Between Groups	.859	2	.429	.360	.699
	Within Groups	88.388	74	1.194		
	Total	89.247	76			
F19	Between Groups	.460	2	.230	.199	.820
	Within Groups	85.488	74	1.155		
	Total	85.948	76			

Table 14.13 ANOVA Analysis (F-value and significant value) of Financial Risks Based on Role in Organisation

14.3.4 Occupant Dissatisfaction Emerging Risks

The results of the ANOVA analysis of the occupant dissatisfaction risk factors are illustrated in Table 14.14, along with the full results, as detailed in Appendix D. The results confirm that the Fs value for emerging occupant dissatisfaction risks was significant, and the likelihood occurrence of their effects was the same for all three roles in originations as p-value>0.05. This indicates that the likelihood of occurrence impact of occupant dissatisfaction risks did not change due to the three groups of professionals; therefore, the Ha_2 hypothesis is accepted for the emerging risks of occupant dissatisfaction.

		Sum of Squares	df	Mean Square	F	Sig.
O1	Between Groups	1.539	2	.770	.838	.437
	Within Groups	67.993	74	.919		
	Total	69.532	76			
O2	Between Groups	3.342	2	1.671	1.531	.223
	Within Groups	80.788	74	1.092		
	Total	84.130	76			

Table 14.14 ANOVA Analysis (F-value and significant value) of Occupant Dissatisfaction Risks Based on Role in Organisation

14.3.5 Liability and Responsibility Emerging Risks

The result ranking based on professional roles in organisations of the liability and responsibility risks in previous chapters showed that there are some differences between the groups of responses. For this reason, the ANOVA test was carried out in order to justify the group responses through testing the research hypotheses. The result of the test given in Table 14.15 is based on the analysis of the three professional role in organisations, which shows that 2 of the 6 differed significantly, namely **LR3 'Increase of claims in contract or tort because buildings designed, or operated in a way that has insufficient regard to the reasonably anticipated impacts of climate change'** and **LR5 'Increasing decommissioning liabilities'** the difference was significant where F=3.244 with p-value=.045 and F=4.424 with p-value=.015, respectively. The Post Hoc Tukey test, as given in Table 14.16, was used to determine which professional role group is different from the others. This test confirmed that the likelihood occurrence of **LR3** impact was lower amongst the risk managers than the other professional roles as p-value=0.034. Moreover, for **LR5**, the facility managers showed higher concern about the likelihood occurrence impact of **LR5** than the risk managers where p-value=.016, whilst risk managers showed lower concern of its likely risk impact than other professional roles as p-value=0.035.

		Sum of Squares	df	Mean Square	F	Sig.
LR3	Between Groups	7.149	2	3.574	3.244	.045
	Within Groups	81.527	74	1.102		
	Total	88.675	76			
LR5	Between Groups	8.813	2	4.407	4.424	.015
	Within Groups	73.706	74	.996		
	Total	82.519	76			

Table 14.15 ANOVA Analysis (F-value and significant value) of Liability & Responsibility Risks based on Role in Organisation

LR3				
(I) role in organisation	**(J)** role in organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Facility manager	Risk manager	-.624-	.351	.185
	Other	.184	.279	.787
Risk manager	Facility manager	.624	.351	.185
	Other	.808*	.318	.034
Other	Facility manager	-.184-	.279	.787
	Risk manager	-.808-*	.318	.034

LR5				
(I) role in organisation	**(J)** role in organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Facility manager	Risk manager	-.948-*	.334	.016
	Other	-.182-	.265	.772
Risk manager	Facility manager	.948*	.334	.016
	Other	.767*	.302	.035
Other	Facility manager	.182	.265	.772
	Risk manager	-.767-*	.302	.035

*The mean difference is significant at the 0.05 level.

LR3 Increase of claims in contract or tort because buildings designed, or operated in a way that has insufficient regard to the reasonably anticipated impacts of climate change.
LR5 Increasing decommissioning liabilities.

Table 14.16 Multiple Comparisons Test by Tukey HSD

14.3.6 Reputational Emerging Risks

The ANOVA method was applied in order to establish the significant difference amongst the professional roles. The result ranking of the reputational risks in previous chapters, based on respondents' role in organisations, showed that there are some differences between the group of responses. The results of the test of important reputational risk factors, as presented in Table 14.17, show that the only significant difference was observed for 2 out of 15 emerging reputational risks. These two factors are **R4 'loss of organisations' sustainability credential'** and **R13 'increased carbon emissions'**, where F=5.202 with p-value=.0088 and F=3.28 with p-value=.043, respectively. Hence, the Ha_{02} hypothesis was accepted for these emerging risk factors. In other words, H_0 was accepted for the rest of the emerging regulation risks. Furthermore, in order to determine which professional role group is different from the others, the Post Hoc Tukey test was used. The results are shown in Table 14.18. From the results, the significant difference was established between the facility managers and risk managers (p-value=.017) where facility managers show higher concern than risk managers.

		Sum of Squares	df	Mean Square	F	Sig.
R4	Between Groups	10.005	2	5.003	5.202	.008
	Within Groups	71.164	74	.962		
	Total	81.169	76			
R9	Between Groups	1.506	2	.753	1.494	.231
	Within Groups	37.299	74	.504		
	Total	38.805	76			
R13	Between Groups	5.944	2	2.972	3.286	.043
	Within Groups	66.939	74	.905		
	Total	72.883	76			
R14	Between Groups	1.084	2	.542	.609	.546
	Within Groups	65.799	74	.889		
	Total	66.883	76			

Table 14.17 ANOVA analysis (F-value and significant value) of Reputational Risks Based on Role in Organisation

R4				
(I) role in organisation	(J) role in organisation	Mean Difference (I-J)	Std. Error	Sig.
Facility manager	Risk manager	-.927-*	.328	.017
	Other	-.027-	.260	.994
Risk manager	Facility manager	.927*	.328	.017
	Other	.900*	.297	.009
Other	Facility manager	.027	.260	.994
	Risk manager	-.900-*	.297	.009

R13				
(I) role in organisation	(J) role in organisation	Mean Difference (I-J)	Std. Error	Sig.
Facility manager	Risk manager	-.127-	.318	.916
	Other	.498	.252	.126
Risk manager	Facility manager	.127	.318	.916
	Other	.625	.288	.083
Other	Facility manager	-.498-	.252	.126
	Risk manager	-.625-	.288	.083

*The mean difference is significant at the 0.05 level.

R4 Loss of organisations' sustainability credential
R13 Increased carbon emissions

Table 14.18 Multiple Comparisons Test by Tukey HSD

14.3.7 Regulatory Emerging Risks

The ANOVA analysis results of the emerging operational risks are given in Table 14.19 below. The results of the ANOVA test indicate that there was significant difference in 4 of 7 of the emerging regulation risks. These four risks factor are **RE3 'Stringent regulation in relation to overheating stress'** where F=4.481 with p-value=.015, **RE4 'Stringent regulation in relation to windstorms stress'** where F=4.424 with p-value=.015, **RE6 'Mandatory climate change risk- appropriate building regulation'** where F=4.772 with p-value=.011 and **RE7 'Uncertainty of pending legislation on climate change'** where F=3.227 with p-value=.045. Therefore, Ha_{02} hypothesis was accepted for these risk statements after using the Post Hoc Tukey test, as given in Table 14.20, in order to determine which professional role group is different from the others. The significant difference in **RE3** was identified between the risk managers and other professionals as p-value =0.023, where risk managers showed less concern. In addition, the facility managers and other managers showed significant difference (p-value=.024) in terms **RE4**, where the other professionals showed more concern. For **RE6**, the risk managers and other professionals showed significant difference as the p-value=.017, where the facility and risk managers showed less concern.

		Sum of Squares	df	Mean Square	F	Sig.
RE1	Between Groups	2.151	2	1.075	1.405	.252
	Within Groups	56.655	74	.766		
	Total	58.805	76			
RE2	Between Groups	2.551	2	1.276	1.290	.281
	Within Groups	73.163	74	.989		
	Total	75.714	76			
RE3	Between Groups	7.688	2	3.844	4.481	.015
	Within Groups	63.481	74	.858		
	Total	71.169	76			
RE4	Between Groups	8.558	2	4.279	4.424	.015
	Within Groups	71.572	74	.967		
	Total	80.130	76			
RE5	Between Groups	.775	2	.387	.530	.591
	Within Groups	54.108	74	.731		
	Total	54.883	76			
RE6	Between Groups	5.139	2	2.570	4.772	.011
	Within Groups	39.848	74	.538		
	Total	44.987	76			
RE7	Between Groups	3.967	2	1.983	3.227	.045
	Within Groups	45.488	74	.615		
	Total	49.455	76			

Table 14.19 ANOVA Analysis (F-value and significant value) of Regulatory Risks Based on Role in Organisation

RE3				
(I) role in organisation	**(J)** role in organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Facility manager	Risk manager	-.252-	.310	.697
	Other	.507	.246	.105
Risk manager	Facility manager	.252	.310	.697
	Other	.758*	.280	.023
Other	Facility manager	-.507-	.246	.105
	Risk manager	-.758-*	.280	.023

RE4				
(I) role in organisation	**(J)** role in organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Facility manager	Risk manager	.094	.329	.956
	Other	.702*	.261	.024
Risk manager	Facility manager	-.094-	.329	.956
	Other	.608	.298	.109
Other	Facility manager	-.702-*	.261	.024
	Risk manager	-.608-	.298	.109

RE6				
(I) role in organisation	**(J)** role in organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Facility manager	Risk manager	-.218-	.246	.650
	Other	.407	.195	.099
Risk manager	Facility manager	.218	.246	.650
	Other	.625*	.222	.017
Other	Facility manager	-.407-	.195	.099
	Risk manager	-.625-*	.222	.017

RE7				
(I) role in organisation	**(J)** role in organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Facility manager	Risk manager	-.021-	.263	.996
	Other	.445	.208	.089
Risk manager	Facility manager	.021	.263	.996
	Other	.467	.237	.128
Other	Facility manager	-.445-	.208	.089
	Risk manager	-.467-	.237	.128

* The mean difference is significant at the 0.05 level.

RE3 Stringent regulation in relation to overheating stress
RE4 Stringent regulation in relation to windstorms stress
RE6 Mandatory climate change risk- appropriate building regulation
RE7 Uncertainty of pending legislation on climate change

Table 14.20 Multiple Comparisons Test by Tukey HSD

14.4 ANOVAs Rating Occurrence Time-Frame

For the purpose of this chapter and to facilitate more manageable discussions, the top 30 emerging risk factors ranked by the respondents, as presented in the previous chapter, were tested through the use of the ANOVA method, and presented in this chapter in terms of the occurrence timeframe of the risks emerging from CCS. However, the full results of the ANOVA test will be illustrated in Appendix D. The ANOVAs test will be based on both the type of organisation and the professional roles across organisations. This will be illustrated and discussed below.

14.4.1 ANOVAs Rating Occurrence Time-Frame Based on type of organisation

This section centres on the completion of the ANOVA analysis based on the types of organisation for respondents so as to establish the significant difference between all types of organisation or sector, including public, private and other institutions. The main hypothesis is as follows:

Hb_0 ($p > 0.05$): there is no significant difference between respondents (types of organisations) in terms of the rating for the occurrence timeframe of emerging risks from climate change.

Hb_1 ($p < 0.05$): there is significant difference between respondents (types of organisations) in terms of the rating for the occurrence timeframe of emerging risks from climate change.

		Sum of Squares	df	Mean Square	F	Sig.
OP2	Between Groups	.105	2	.052	.307	.737
	Within Groups	12.597	74	.170		
	Total	12.701	76			
OP3	Between Groups	.795	2	.398	1.634	.202
	Within Groups	18.010	74	.243		
	Total	18.805	76			
OP1	Between Groups	1.598	2	.799	1.992	.144
	Within Groups	29.675	74	.401		
	Total	31.273	76			
OP5	Between Groups	.754	2	.377	.938	.396
	Within Groups	29.765	74	.402		
	Total	30.519	76			
PH24	Between Groups	3.171	2	1.586	.839	.436
	Within Groups	139.920	74	1.891		
	Total	143.091	76			

OP18	Between Groups	3.250	2	1.625	1.215	.303
	Within Groups	97.631	73	1.337		
	Total	100.882	75			
OP6	Between Groups	5.790	2	2.895	6.068	.004
	Within Groups	35.301	74	.477		
	Total	41.091	76			
OP4	Between Groups	.318	2	.159	.233	.793
	Within Groups	50.540	74	.683		
	Total	50.857	76			
O1	Between Groups	1.170	2	.585	.908	.408
	Within Groups	47.687	74	.644		
	Total	48.857	76			
F19	Between Groups	.151	2	.076	.106	.899
	Within Groups	52.550	74	.710		
	Total	52.701	76			
R13	Between Groups	2.208	2	1.104	1.624	.204
	Within Groups	50.311	74	.680		
	Total	52.519	76			
RE7	Between Groups	.266	2	.133	.204	.816
	Within Groups	48.254	74	.652		
	Total	48.519	76			
PH36	Between Groups	3.274	2	1.637	1.857	.163
	Within Groups	65.245	74	.882		
	Total	68.519	76			
O2	Between Groups	2.002	2	1.001	1.270	.287
	Within Groups	58.310	74	.788		
	Total	60.312	76			
PH17	Between Groups	.143	2	.072	.102	.904
	Within Groups	52.169	74	.705		
	Total	52.312	76			
PH34	Between Groups	.273	2	.137	.086	.918
	Within Groups	117.805	74	1.592		
	Total	118.078	76			
F17	Between Groups	.463	2	.231	.458	.634
	Within Groups	37.355	74	.505		
	Total	37.818	76			
PH35	Between Groups	.578	2	.289	.151	.860
	Within Groups	141.241	74	1.909		
	Total	141.818	76			
PH25	Between Groups	1.927	2	.964	.477	.623
	Within Groups	149.605	74	2.022		
	Total	151.532	76			
PH18	Between Groups	1.690	2	.845	.847	.433
	Within Groups	73.842	74	.998		
	Total	75.532	76			
PH2	Between Groups	.598	2	.299	.149	.862
	Within Groups	148.285	74	2.004		
	Total	148.883	76			
OP8	Between Groups	.717	2	.359	.579	.563
	Within Groups	45.802	74	.619		
	Total	46.519	76			
PH23	Between Groups	.357	2	.179	.220	.803
	Within Groups	60.162	74	.813		
	Total	60.519	76			
LR1	Between Groups	4.476	2	2.238	1.824	.169

	Within Groups	90.796	74	1.227		
	Total	95.273	76			
F16	Between Groups	5.991	2	2.996	4.010	.022
	Within Groups	55.281	74	.747		
	Total	61.273	76			
R14	Between Groups	1.029	2	.515	.597	.553
	Within Groups	63.776	74	.862		
	Total	64.805	76			
F9	Between Groups	1.702	2	.851	.580	.563
	Within Groups	108.610	74	1.468		
	Total	110.312	76			
PH28	Between Groups	5.144	2	2.572	1.552	.219
	Within Groups	122.649	74	1.657		
	Total	127.792	76			
PH20	Between Groups	1.416	2	.708	.724	.488
	Within Groups	72.376	74	.978		
	Total	73.792	76			

Table 14.21 ANOVA Analysis (F-value and significant value) of Top Ranked Risks (Occurrence Time-frame) Based on Type of Organisation

The ANOVA analysis results of the top 30 ranked emerging risk factors, as based on timescale, are given in Table 14.21 above. The results of the ANOVA test indicate that there is significant difference in only 2 of the 30 top ranked emerging risks of climate change. These two risk factors are **OP6** and **F16** where F=6.068 with p-value=0.004 and F=4.010 with p-value=0.022, respectively.

OP6				
(I) Type of organisation	**(J)** Type of organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Private	Public	.671*	.194	.003
	Other	.604	.267	.068
Public	Private	-.671-*	.194	.003
	Other	-.067-	.230	.955
Other	Private	-.604-	.267	.068
	Public	.067	.230	.955

F16				
(I) Type of organisation	**(J)** Type of organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Private	Public	-.251-	.243	.560
	Other	.556	.334	.226
Public	Private	.251	.243	.560
	Other	.807*	.288	.018
Other	Private	-.556-	.334	.226
	Public	-.807-*	.288	.018

* The mean difference is significant at the 0.05 level.

OP6 Increased maintenance regimes
F16 Increase costs to purchase

Table 14.22 Multiple Comparisons Test by Tukey HSD

Therefore, the null hypothesis (Hb_0) was accepted for the timeframe of the emerging risks of climate change after utilising the Post Hoc Tukey test given in Table 14.22 for these two risk factors in order to determine which type of organisation group is different to the others. The significant difference in **OP6** was between public and private organisations as p-value =0.003, where the public organisations were seen to show more concern in terms of the impact of this emerging factor. In addition, the public and other organisation showed a significant difference (p-value=.018) in terms of **F16**, where other organisations showed more concern.

14.4.2 ANOVAs Rating Occurrence Time-Frame Based on Professional Roles

The ANOVA analysis has also been used to test the top 30 emerging risk factors. This tested the following hypothesis:

Hb_2 ($p > 0.05$): there is no significant difference between respondents (professional roles in organisations) in terms of the rating for the occurrence timeframe of emerging risks from climate change.

Hb_{02} ($p < 0.05$): there is significant difference between respondents (professional roles in organisations) in terms of the rating for the occurrence timeframe of emerging risks from climate change.

The results of this analysis are illustrated in Table 14.23 below. The results confirm that the Fs value for the top 30 emerging risks of climate change were significant, and the likelihood occurrence timescale of their effects were the same for all three roles in originations as p-value >0.05. This indicates that the timeframe of the emergence of impacts from emerging risks on buildings and real estate did not change due to the three groups of professionals (facility managers, risk managers and other professional roles). Therefore, the *Hb_2* hypothesis is accepted for these top 30 ranked emerging risks of climate change.

		Sum of Squares	df	Mean Square	F	Sig.
OP2	Between Groups	.079	2	.040	.230	.795
	Within Groups	12.605	73	.173		
	Total	12.684	75			
OP3	Between Groups	.190	2	.095	.375	.689
	Within Groups	18.546	73	.254		
	Total	18.737	75			
OP1	Between Groups	.179	2	.089	.232	.793
	Within Groups	28.071	73	.385		
	Total	28.250	75			

OP5	Between Groups	.988	2	.494	1.338	.269
	Within Groups	26.946	73	.369		
	Total	27.934	75			
PH24	Between Groups	1.628	2	.814	.427	.654
	Within Groups	139.043	73	1.905		
	Total	140.671	75			
OP18	Between Groups	4.697	2	2.348	1.803	.172
	Within Groups	93.783	72	1.303		
	Total	98.480	74			
OP6	Between Groups	2.440	2	1.220	2.317	.106
	Within Groups	38.442	73	.527		
	Total	40.882	75			
OP4	Between Groups	.100	2	.050	.072	.931
	Within Groups	50.571	73	.693		
	Total	50.671	75			
O1	Between Groups	.643	2	.322	.509	.603
	Within Groups	46.146	73	.632		
	Total	46.789	75			
F19	Between Groups	1.384	2	.692	.991	.376
	Within Groups	50.971	73	.698		
	Total	52.355	75			
R13	Between Groups	.983	2	.492	.725	.488
	Within Groups	49.543	73	.679		
	Total	50.526	75			
RE7	Between Groups	.983	2	.492	.788	.458
	Within Groups	45.543	73	.624		
	Total	46.526	75			
PH36	Between Groups	3.612	2	1.806	2.037	.138
	Within Groups	64.743	73	.887		
	Total	68.355	75			
O2	Between Groups	3.173	2	1.587	2.033	.138
	Within Groups	56.985	73	.781		
	Total	60.158	75			
PH17	Between Groups	1.320	2	.660	.948	.392
	Within Groups	50.838	73	.696		
	Total	52.158	75			
PH34	Between Groups	4.958	2	2.479	1.627	.203
	Within Groups	111.200	73	1.523		
	Total	116.158	75			
F17	Between Groups	.189	2	.094	.185	.831
	Within Groups	37.219	73	.510		
	Total	37.408	75			
PH35	Between Groups	.921	2	.461	.242	.786
	Within Groups	139.013	73	1.904		
	Total	139.934	75			
PH25	Between Groups	2.800	2	1.400	.700	.500
	Within Groups	145.976	73	2.000		
	Total	148.776	75			
PH18	Between Groups	2.241	2	1.121	1.145	.324
	Within Groups	71.443	73	.979		
	Total	73.684	75			
PH2	Between Groups	3.654	2	1.827	.930	.399
	Within Groups	143.451	73	1.965		
	Total	147.105	75			
OP8	Between Groups	.401	2	.201	.330	.720
	Within Groups	44.375	73	.608		

	Total	44.776	75			
PH23	Between Groups	3.457	2	1.728	2.329	.105
	Within Groups	54.175	73	.742		
	Total	57.632	75			
LR1	Between Groups	1.822	2	.911	.724	.488
	Within Groups	91.810	73	1.258		
	Total	93.632	75			
F16	Between Groups	.626	2	.313	.377	.687
	Within Groups	60.571	73	.830		
	Total	61.197	75			
R14	Between Groups	.399	2	.199	.226	.798
	Within Groups	64.338	73	.881		
	Total	64.737	75			
F9	Between Groups	.324	2	.162	.109	.897
	Within Groups	108.413	73	1.485		
	Total	108.737	75			
PH28	Between Groups	3.774	2	1.887	1.125	.330
	Within Groups	122.476	73	1.678		
	Total	126.250	75			
PH20	Between Groups	4.060	2	2.030	2.226	.115
	Within Groups	66.571	73	.912		
	Total	70.632	75			

Table 14.23 ANOVA Analysis (F-value and significant value) of Top Ranked Risks (Occurrence Time-frame) Based on Professional Roles in Organisation

14.5 Climate Change Risk Management

14.5.1 ANOVAs Rating Based on the Type of Organisation

The climate change risk management contains 24 factors; the result ranking is based on the type of organisation in the previous chapters, which illustrate that there are various differences between respondents. For this reason, the ANOVA method has been applied in an effort to justify the group responses through testing the following hypotheses:

Hc_0 ($p > 0.05$): there is no significant difference between respondents (types of organisations) in terms of the level of effectiveness of CCRM factors.

Hc_1 ($p < 0.05$): there is significant difference between respondents (types of organisations) in terms of the level of effectiveness of CCRM factors.

The Table 14.24 below details the ANOVA test results, indicating that there was no significant difference in the effectiveness of CCRM for the majority of statements of CCRM due to the three organisations. In particular, the respondents from the three organisations shared the view of the level effectiveness of CCRM strategies in relation to the impacts of CCR. Therefore, Hc_0 hypothesis is accepted for all statements, except 2 of the 24 CCRM factors. These CCRM factors are **RM13 'plans to deal with changes in market demand'** and **RM22 'concerned with plans to generate renewable energy on site'**, where the difference was significant since F=4.099 with P-value= 0.020 and F=5.255 with p-value=0.007, respectively. Due to these significant differences, the Post Hoc Tukey test was applied, as detailed in Table 14.25, illustrating that the only significant difference was between the public and private organisations as the p-value=.006, meaning the private organisations showed less concern than the public in regard to the effectiveness level of CCRM factors associated with the emerging climate change risks.

		Sum of Squares	df	Mean Square	F	Sig.
RM4	Between Groups	.250	2	.125	.219	.804
	Within Groups	42.929	75	.572		
	Total	43.179	77			
RM5	Between Groups	1.574	2	.787	1.717	.187
	Within Groups	34.375	75	.458		
	Total	35.949	77			
RM7	Between Groups	.711	2	.355	.559	.574
	Within Groups	47.661	75	.635		
	Total	48.372	77			

RM13	Between Groups	5.710	2	2.855	4.099	.020
	Within Groups	52.239	75	.697		
	Total	57.949	77			
RM16	Between Groups	2.074	2	1.037	1.419	.248
	Within Groups	54.810	75	.731		
	Total	56.885	77			
RM17	Between Groups	3.611	2	1.806	2.777	.069
	Within Groups	48.761	75	.650		
	Total	52.372	77			
RM18	Between Groups	1.108	2	.554	.905	.409
	Within Groups	45.880	75	.612		
	Total	46.987	77			
RM20	Between Groups	1.804	2	.902	1.617	.205
	Within Groups	41.849	75	.558		
	Total	43.654	77			
RM21	Between Groups	1.612	2	.806	1.104	.337
	Within Groups	54.760	75	.730		
	Total	56.372	77			
RM22	Between Groups	8.441	2	4.220	5.255	.007
	Within Groups	60.239	75	.803		
	Total	68.679	77			
RM23	Between Groups	1.001	2	.500	.767	.468
	Within Groups	48.948	75	.653		
	Total	49.949	77			
RM24	Between Groups	3.476	2	1.738	2.190	.119
	Within Groups	59.511	75	.793		
	Total	62.987	77			

Table 14.24 ANOVA Analysis (F-value and significant value) of CCRM Factors Based on Type of Organisation

RM13				
(I) Type of organisation	**(J)** Type of organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Private	Public	.487	.234	.101
	Other	-.171-	.323	.857
Public	Private	-.487-	.234	.101
	Other	-.658-	.278	.053
Other	Private	.171	.323	.857
	Public	.658	.278	.053

RM22				
(I) Type of organisation	**(J)** Type of organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Private	Public	.807*	.251	.006
	Other	.465	.346	.377
Public	Private	-.807*	.251	.006
	Other	-.341	.298	.490
Other	Private	-.465	.346	.377
	Public	.341	.298	.490

* The mean difference is significant at the 0.05 level

RM13 Plans to deal with changes in market demand
RM22 Plans to generate renewable energy on site

Table 14.25 Multiple Comparisons Test by Tukey HSD

14.5.2 ANOVAs Rating Based on the Professional Role

This section's ANOVA analysis is based on respondents' professional role in organisations in order to determine the significant difference between all professional roles (facility manager, risk manager and other roles). This is done in order to test the below hypothesis:

Hc_2 ($p > 0.05$): there is no significant difference between respondents (professional roles in organisations) in terms of the level of effectiveness of CCRM factors.

Hc_{02} ($p < 0.05$): there is significant difference between respondents (professional roles in organisations) in terms of the level of effectiveness of CCRM factors.

According to Table 14.26, the ANOVA test analysis indicates that there was significant difference in 5 of 24 CCRM factors. These are **RM1 'disruption planning'** where F=4.716 with p-value=.012, **RM2 'balancing resources'** where F=5.067 with p-value=.009, **RM8 'adaptation planning'** where F=3.71 with p-value=.029, **RM9 'property portfolio climate change risk management'** where F=4.037 with p-value=.022 and **RM18 'plans to manage water footprint'** as F=4.004 with p-value=.022. Therefore, hypothesis *Hc_{02}* was only accepted for these CCRM factors.

		Sum of Squares	df	Mean Square	F	Sig.
RM1	Between Groups	3.759	2	1.879	4.716	.012
	Within Groups	29.488	74	.398		
	Total	33.247	76			
RM2	Between Groups	4.724	2	2.362	5.067	.009
	Within Groups	34.497	74	.466		
	Total	39.221	76			
RM4	Between Groups	1.851	2	.925	1.657	.198
	Within Groups	41.318	74	.558		
	Total	43.169	76			
RM5	Between Groups	2.751	2	1.376	3.066	.053
	Within Groups	33.197	74	.449		
	Total	35.948	76			
RM7	Between Groups	2.291	2	1.145	1.840	.166
	Within Groups	46.073	74	.623		
	Total	48.364	76			
RM8	Between Groups	5.041	2	2.520	3.701	.029
	Within Groups	50.388	74	.681		
	Total	55.429	76			
RM9	Between Groups	5.123	2	2.562	4.037	.022
	Within Groups	46.955	74	.635		
	Total	52.078	76			
RM16	Between Groups	3.211	2	1.606	2.214	.116
	Within Groups	53.672	74	.725		
	Total	56.883	76			
RM17	Between Groups	2.124	2	1.062	1.566	.216
	Within Groups	50.188	74	.678		
	Total	52.312	76			

RM18	Between Groups	4.588	2	2.294	4.004	.022
	Within Groups	42.399	74	.573		
	Total	46.987	76			
RM20	Between Groups	.926	2	.463	.805	.451
	Within Groups	42.606	74	.576		
	Total	43.532	76			
RM21	Between Groups	1.130	2	.565	.757	.473
	Within Groups	55.233	74	.746		
	Total	56.364	76			
RM23	Between Groups	3.682	2	1.841	2.945	.059
	Within Groups	46.266	74	.625		
	Total	49.948	76			
RM24	Between Groups	1.948	2	.974	1.181	.313
	Within Groups	61.039	74	.825		
	Total	62.987	76			

Table 14.26 ANOVA Analysis (F-value and significant value) of CCRM Factors Based on Role in Organisation

The Post Hoc Tukey test, as given in Table 14.27, was applied in order to determine which professional role group is different from the others. This test confirms that, for **RM1**, there was significant difference between the facility and risk managers as p-value=.014, where the risk managers tended to show greater concern than the facility managers. Moreover, for **RM2**, the risk managers showed greater significant concern than the facility managers (p-value= .030) and other managers (p-value=.013). In addition, concerning the significant difference in **RM8**, the facility managers showed less concern in terms of the effectiveness of this CCRM factor than other professionals (p-value=.039). For **RM9**, the risk managers' concern was significantly greater than that of the facility managers and other professionals, as the p-value=.018. In terms of significant difference in **RM18**, the risk managers showed more concern than the facility managers and other professional managers, where the p-value=.04 and p-value=.045, respectively.

RM1				
(I) role in organisation	**(J)** role in organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Facility manager	Risk manager	.612*	.211	.014
	Other	.395	.168	.054
Risk manager	Facility manager	-.612-*	.211	.014
	Other	-.217-	.191	.497
Other	Facility manager	-.395-	.168	.054
	Risk manager	.217	.191	.497

RM2				
(I) role in organisation	**(J)** role in organisation	Mean Difference **(I-J)**	Std. Error	Sig.
Facility manager	Risk manager	.594*	.229	.030
	Other	.527*	.181	.013
Risk manager	Facility manager	-.594-*	.229	.030
	Other	-.067-	.207	.944
Other	Facility manager	-.527-*	.181	.013
	Risk manager	.067	.207	.944

RM8				
(I) role in organisation	(J) role in organisation	Mean Difference (I-J)	Std. Error	Sig.
Facility manager	Risk manager	.612	.276	.075
	Other	.545*	.219	.039
Risk manager	Facility manager	-.612-	.276	.075
	Other	-.067-	.250	.962
Other	Facility manager	-.545-*	.219	.039
	Risk manager	.067	.250	.962

RM9				
(I) role in organisation	(J) role in organisation	Mean Difference (I-J)	Std. Error	Sig.
Facility manager	Risk manager	.745*	.267	.018
	Other	.395	.211	.155
Risk manager	Facility manager	-.745-*	.267	.018
	Other	-.350-	.241	.320
Other	Facility manager	-.395-	.211	.155
	Risk manager	.350	.241	.320

RM18				
(I) role in organisation	(J) role in organisation	Mean Difference (I-J)	Std. Error	Sig.
Facility manager	Risk manager	.630*	.253	.040
	Other	.488*	.200	.045
Risk manager	Facility manager	-.630-*	.253	.040
	Other	-.141-	.229	.811
Other	Facility manager	-.488-*	.200	.045
	Risk manager	.141	.229	.811

* The mean difference is significant at the 0.05 level.

RM1 Disruption planning
RM2 Balancing resources
RM8 Adaptation planning
RM9 Property portfolio climate change risk management
RM18 Plans to manage water footprint

Table 14.27 Multiple Comparisons Test by Tukey HSD

14.6 Summary of this Chapter

This chapter of the research project presented and described the hypotheses tested through the use of the one-way ANOVA method in an effort to establish the significant difference between the groups of respondent. There was no significant difference established between the groups of respondent concerning the likelihood occurrence of emerging risks of climate change except three factors, namely **OP13, F19** and **R14** of 112 emerging risks factors. In addition, only two risk factors were found to have significant differences; these are OP6 and F16. This is considered a low percentage of significant difference, and therefore indicates that all types of organisation are concerned with the impacts of the risks emerging from climate change, and their occurrence timeframe. Moreover, in regard to the rating by the professional roles, significant difference was identified in 13 of 112 emerging risk factors concerning the general likelihood of emergence. These emerging risk factors are **PH8, PH12, PH13, PH14, PH15, LR3, LR5, R4, R13, RE3, RE4, RE6** and **RE7**. Nonetheless, there was no significant difference established between professional roles in organisations, in regard to the likelihood occurrence timescale of risks emerging from CCS. These percentages of significant difference were not overly high, thus confirming that there is an agreement between professional roles in regard to the likelihood of occurrence of emerging risks of climate change on buildings and real estate.

The last part of this chapter centred on the ANOVA analysis for climate change risk management factors. The ANOVA test results present that only 2 of 24 CCRM factors encompassed significant difference amongst the types of organisation; these factors are **RM13** and **RM22**, as illustrated previously. In other words, there is an agreement between the respondents from all types of organisation—concerning the effectiveness of CCRM in mitigating and adapting buildings—and real estate with the risks emerging from climate change. However, there are 5 CCRM factors significantly different, based on professional roles. These CCRM factors are RM1, RM2, RM8, RM9 and RM18 as presented precisely in this chapter.

CHAPTER 15: DISCUSSION

15.1 Introduction

The main aim of this research project was to uncover the important emerging risks on the buildings industry as a result of climate change scenarios, as well as to identify their likelihood of impacts and their occurrence timeframe on buildings and real estate. The project also sought to identify the effectiveness of climate change risk management factors in assisting the building sector to mitigate and adapt buildings and real estate was to be established in regard to the potential risks emerging from climate change patterns. The perceptions of professionals (participants in the study) concerning the likelihood of impacts of the risks emerging from climate change and their occurrence timeframe on buildings and real estate, along with the effectiveness of climate change risk management strategies, have also been discussed in previous chapters.

This chapter is dedicated to discussing the pivotal findings of the research as a whole through comparing findings from the literature review of this research project with the results of the data analysis.

15.2 The Subject of Climate Change and the Building Sector

Climate change and its potential impacts are becoming global issues, as this can impact many sectors and levels of society across the world (Midgley *et al.*, 2005; Brown *et al.*, 2011; De Wilde and Coley, 2012). However, fundamentally, the impacts and effects from climate change scenarios on buildings and real estate are crucial and more serious than this contribution (Capon and Oakley, 2012; De Wilde and Coley, 2012; Steenbergen *et al.*, 2012). The absence of the determinants of such risks and forecasts of the future climate change scenarios, as based on climate studies and recordings, would ultimately exacerbate the problem in the building sector.

Previous researches and studies demonstrate that there is a clear correlation between climate change scenarios and the building sector in terms of both the emerging risks from CC on buildings and real estate, and the contribution of the building sector to the causes of CC, such as CO_2. Hence, it is surprising to see that there is no agreed upon guideline in the building sector in relation to the impacts of climate change scenarios risks and on buildings and real estate in particular. Ignoring the presence and seriousness of climate change scenarios on buildings and real estate, and taking only the current or previous experience in facing the potential risks of climate change patterns, will lead to greater damage and further risks, which might destroy buildings and real estate in certain circumstances of climate change scenarios.

15.3 The Emerging Risk of CC Constructs

The available literature review in regard to the risks emerging from climate change indicate that these emerging risks and their potential impacts on buildings and real estate are unclear, and seem to be as semi-anonymous for both professionals and practitioners in the building sector, such as amongst designers, architectures, advisors, owners, managers and even investors. Several research and studies—such as those by Garvin *et al*., (1998), Crawley (2003), Hacker *et al*., (2005), Martin *et al*., (2009) and Hunt and Watkiss (2011)—claimed that the risks from climate change scenarios and their frequency and magnitude in the building sector still remain unclear and need further details and clarification, which is why this research focuses on the study of the projected scenarios of climate change, which is considered the main driver for the emergence of the various climate change risks on the building sector. Based on this, the potential risks of climate change patterns on buildings and real estate, and the occurrence timescale of their likelihood emergence, has been explored, clarified and divided in terms of classification, depending on several factors, such as the kind of risk, vulnerability of buildings and real estate, and their facility and vulnerable users to such risks, either directly or indirectly.

In the case of facing different risks of climate change on buildings and real estate with the absence of a structured framework exacerbates the problem and makes it more difficult and dangerous for professionals and practitioners in the building sector. These difficulties—especially for managers, such as risk and facility managers—include identifying and analysing the potential risks from climate change scenarios and finding ways and strategies of protecting or adapting buildings and real estate with such risks.

In addition to the above arguments, most of the climate change risks on buildings and real estate overlap where they affect or cause each other, thus leading to increases in the possibility of failure to protect buildings or real estate, as well as the occupants.

In this research, the risks emerging from climate change scenarios are classified practically in terms of the mentioned criteria (see chapters 4–11). Understanding and accommodating these potential risks from climate change patterns on the building sector will assist architects, designers, managers and owners in protecting existing premises and accordingly will encourage decision makers to take into account such risks in future projects.

The previous researches and studies have shown (as reviewed in chapters of the literature review in this research) that the risk of climate change caused several risks to buildings and real estate, such as physical risks, operational risks and regulatory and reputation risks. This leads to blaming professionals at all levels in the building sector, who might face various additional risks and effects. It could be argued that it is worthwhile for concentrated efforts to be directed towards unifying the efforts and approaches to confront and deal with such risks. Therefore, the potential risks emerging from climate change patterns play a crucial role in affecting the building sector at all levels. Hence, this research provides the compensation of existing weaknesses in data and information available in the building sector in relation to the risks emerging from climate change scenarios on buildings and real estate in particular, and further translate this in the practical classification list of these risks.

15.4 The Emerging Risks of Climate Change Classifications

The building sector induces physical risks from climate change scenarios that affect buildings and real estate more so than other risks. According to Martin *et al.,* (2009), the emerging physical risks are well-documented and clarified in terms of their impacts and effects on buildings and real estate. Consequently, this research project directs pivotal concern to the risks emerging from climate change scenarios and their expected influences on the building sector. More specifically, this study focuses on the risks emerging from climate change patterns, which damage buildings and real estate in terms of their elements, components and performance of the design and operational roles of such property. Moreover, there are adverse impacts on occupants, as well as on those in charge of buildings and real estate, such as architects, designers, owners and managers. Along with information and data gathered from the literature review, the questionnaire was divided into seven clusters, as per the classification of the risks emerging from climate change (physical, operation, occupant dissatisfaction, liability and responsibility risks, reputation risks and regulation risks).

15.4.1 Physical Emerging Risks

The literature review in this research project confirmed that most of the studies and researches centred on the risks of climate change in the building sector focus more so on the physical risks, as highlighted by Garvin *et al.,* 1998; Graves and Phillipson, 2000; Wingfield *et al.*, 2005; Ross *et al.,* 2007; Szyman and McNamara, 2008; Horváth and Pálvölgyi, 2011; Hallett, 2013). In addition, the physical risks group is one of the clearest risks arising from the effects of climate change scenarios on the building sector, and inflicts direct risks and damages upon buildings and real estate, as well as on their elements and components. Moreover, it is also considered one of the emerging risks positioned as the first line of concern and attention from practitioners and professionals in the building sector, such as owners, managers, constructors and designers, due to their crucial impacts and damages. The reason behind this is that the physical risks are highly expected to appear in different points of time, starting from the initial exposing of buildings or real estate to one of the scenarios of climate change, such as flooding or severe changes in temperature.

According to findings from the data analysis, all of the emerging risks in this study are likely to occur due to the effects of different climate change scenarios on buildings and real estate. Moreover, across all groups of respondent, there were no significant differences regarding the likelihood of the occurrence of physical emerging risks and the timescale of emergence. However, the data findings indicate that it appears that risk managers view the emerging physical risks differently from other professionals, such as owners, architects and designers. This disagreement could be seen in 5 out of 37 physical emerging risks, as illustrated in Table 15.1 below; this significant difference could be due to the experience and duties of risk managers towards their property. This also implies that identifying and dealing with physical risks on buildings is based on the professional role and responsibility in the process of buildings and real estate performance lifecycle. Moreover, as discussed in the results section, physical risks emergence is positively related to the view expressed by the professional/employee in organisations/institutions. Hence, it would be useful to take into account the potential emerging physical risks for both existing premise and new assets projects. This will result in coping with these emerging risks—or even other emerging risks.

Additionally, one strategy that may increase the awareness of risk emergence is to explicitly and periodically assess how each risk factor profile changes over time. One of the challenges facing the practice in the building sector in terms of detecting risks emerging from CCS is that building asset owners are driven by demonstrable outcomes; usually, if a risk is perceived as having low impacts or damages, it might be overlooked by property managers, despite the fact that the physical risk state may change over time, based on the magnitude impacts of CCS, as suggested by CIBSE, 2005; Graves and Phillipson, 2000.

Research Question	Is there a significant difference between the groups of respondents regarding the likelihood occurrence of physical emerging risks that were identified based on their professional role and type of their organisation?
Hypothesis	*Ha_0 ($p > 0.05$): there is no significant difference between respondents in terms of the rating for the likelihood of the occurrence of risks emerging from climate change.*
Results	The ANOVA results indicated that: There were significant differences between the respondents based on 5 of the physical emerging risks, which are namely PH8, PH12, PH13, PH14 & PH15 based on their professional role.
Researcher Observation	The physical emerging risks were identified based on a comprehensive literature review. • The respondents based on their professional roles have different concern on these 5 factors that were rejected. • These rejected factor are related to subsidence and heave movement, which might have serous damages to the foundation and facades of buildings and real estate. • The different concern from professional roles could be as a result of their specialties or responsibilities in managing property where the differences were observed between facility managers and risk managers. • Also the facility managers have more concern about these risk factors which confirmed that they more aware and knowledgeable about the severity of such physical risks on buildings' performance. Hence, the different experiences of participants could affect the rejection of these indicators.
Conclusion	The null hypotheses *Ha_0* was rejected for these indicators.

Table 15.1 Research Question about Physical Risks and Related Hypotheses Results.

15.4.2 Operational Emerging Risks

The factors within this cluster are those related to the operation stage of the buildings and real estate. These emerging risks revolve around the facilities management of property, the availability of resources needed in the operation phase of buildings and real estate, as well as maintenance and replacement activities. The operational risks emerging from climate change patterns are positioned at the top in terms of the concerns and worries of practitioners in the building sector, and facility and technical managers in particular (Hertin *et al.*, 2003). This concern is also confirmed by the majority of participants in the survey of this study, with 11 out of 18 operational risks observed in the top 30 ranked risks emerging from climate change patterns on buildings and real estate. The data also claims that the majority of respondents—approximately 89.6%–67.5%—advised that **OP2, OP3, OP1** and **OP5** risks—namely higher energy cost, increasing water costs, increase in energy use and higher costs of repair—will arise within the next 5 years. The implication of this on performance and operation processes of buildings and real estate might increase the disruption of affected property, which is a view supported by Tubb *et al.*, (2003), Vivian *et al.*, (2005) and Chalmers *et al.*, (2009) all of whom declare that the emergence of operational risks will result in reduced access to assets and increased possibility of downtime.

Moreover, the data analysis in this research project present that only one operation risk, which is **OP13**, has significant differences between the private sector and other organisations, such as charity, whilst public and private organisations show less concern in regards to this operational risk, as explained in Table 15.2 below.

	Likelihood impacts	Time frame occurrence
Research Question	Is there a significant difference between the groups of respondents regarding the likelihood occurrence of operational emerging risks that were identified based on their professional role and type of their organisation?	Is there a significant difference between the groups of respondents regarding the occurrence timescale of operational emerging risks that were identified based on their professional role and type of their organisation?
Hypothesis	*Ha_0 ($p > 0.05$): there is no significant difference between respondents in terms of the rating for the likelihood of the occurrence of risks emerging from climate change.*	*Hb_0 ($p > 0.05$): there is no significant difference between respondents in terms of the rating for the occurrence timeframe of risks emerging from climate change.*
Results	The ANOVA results indicated that: There were significant differences between the respondents in terms of the type of their organisation based on one of the 18th operational emerging risks, which is namely OP13.	The result of analysis using one way ANOVA determined that there were significant differences between public and private sector on one operation risk namely OP6
Researchers' Observation	• Organisations otherwise public and private organisations have more concern in regard to the rejected operational risk. • The fact that this operation risk respect to sanitation and public and private is not worried about the emergence of this threat and its effects as they have plans and owned infrastructure projects for their buildings and real estate in contrast to other sectors and institutions.	• Public sector highly expected the emergence of this operation factor due to several reasons such as risks frequency and high expectation to strict regulations in order to adapting buildings and real estate.
Conclusion	The null hypotheses *Ha_0* was rejected for this operation emerging risk factor.	The null hypotheses *Hb_0* was rejected for this operation emerging risk factor.

Table 15.2 Research Question about Operational Risks and Related Hypotheses Results.

Taking the potential operational risks into account—especially at the functional and operational phases of assets—reflects positively on insuring the performance of buildings or real estate, as intended in the design and construction. Furthermore, when keeping in mind these operational emerging risks, especially facility managers in the early stages of the operation phase in a building's lifecycle, several risks emerging from climate change scenarios will be avoided, increasing the performance of buildings in relation to energy consumption and the availability of the resources in particular. The adoption of these indicators in the operation phase of property lifecycle will lead to controlled and managed GHGs emissions from buildings and real estate.

15.4.3 Financial Emerging Risks

Financial risks are the emerging risks related to the cost of other emerging risks on buildings and real estate, such as physical, operation and reputational risks. The literature review in this research project claims that the financial risks emerging from climate change will have both direct and indirect emerging risks, impacting buildings and real estate. The direct risks include costs of the repair of damage or the replacement of key components (Graves and Phillipson, 2000; Gill *et al.*, 2004; ABI, 2005) indirect emerging financial risks, on the other hand, are those related to occupant and employee productivity (Capon and Oakley, 2012; Land Use Consultants, 2006) and insurance problems (Graves and Phillipson, 2000; Tubb *et al.*, 2003; CCRA, 2012; Repetto, 2012).

According to the analysis of the questionnaire findings, the financial emerging risks are highly likely to occur in the building sector, where around 40% of the participants in this study indicated that around one-third of the total identified financial risks (23 factors) would emerge within 5–10 years, where the most two important factor are **F17** and **F19**, namely increased insurance excess and additional expense in insuring buildings in flood risk zones, whilst the least two important financial risks are **F2** and **F21**, namely unable to repay debts and un-insurability due to climate change. The level of financial emerging risks is based on several drivers, such as severity and magnitude of the climate change scenarios' impacts on property and the level of vulnerability of buildings and real estate to such impacts and risks. Furthermore, across all groups of respondent, the emerging financial risks achieve a significant degree of attention and concern—especially in private organisations and for facility and risk managers. The explanation for the main significant findings is detailed in Table 15.3.

This implies that the implications of financial emerging risks on assets will have significant impacts—especially on owners and investors, as well as occupiers. This view is supported by Szyman and McNamara (2008), who point out that buildings and real estate that are suffering from financial emerging risks will become less attractive to occupants, owners and investors due to their energy consumption, increased costs for resources, and the materials required for maintenance or repairs. In addition, one strategy that may reduce the vulnerability of assets to emerging financial risks from CCS is to periodically maintain property, as well as assess each other's risk factors arising in terms of their costs.

The challenge facing this strategy is that the owners and investors are looking to achieve higher level of profit from their buildings—even with low quality solutions for such risks, which will exacerbate the financial problems; the managers responsible for providing practical and effective solutions, as well as improving buildings' adaptability to emerging risks, help to minimise the impacts of financial risks.

	Likelihood impacts	Timeframe occurrence
Research Question	Is there a significant difference between the groups of respondents regarding the likelihood occurrence of financial emerging risks that were identified based on their professional role and type of their organisation?	Is there a significant difference between the groups of respondents regarding the occurrence timescale of financial emerging risks that were identified based on their professional role and type of their organisation?
Hypothesis	*Ha_0 ($p > 0.05$): there is no significant difference between respondents in terms of the rating for the likelihood of the occurrence of risks emerging from climate change.*	*Hb_0 ($p > 0.05$): there is no significant difference between respondents in terms of the rating for the occurrence timeframe of risks emerging from climate change.*
Results	The result of data analysis through one way ANOVA indicated that there were significant differences between public and private sector on one financial risk F19	Also there were significant differences between public and other type of sectors on only one financial risk namely F16 based on its occurrence time frame
Researchers' Observation	• The damages occur from flooding are crucial and its frequency in certain areas lead to increase insurance in such areas. • Public organisations and other institutions put this risk in their top 5 emerging risks this might due to their experience with such risk as well as the as flood considered in the most dangerous climatic patterns.	• Other organisations and institutions are highly expected this emerging risk occur in very early timescale (0-5 years) this expectation is might be due to their experience with climate change risks. • Public and private organisations did not agreed with this expectation as they have strategies in terms avoid this risk such as long-term contracts to secure sources.
Conclusion	The null hypotheses *Ha_0* was rejected for this financial emerging risk factor.	The null hypotheses *Hb_0* was rejected for this financial emerging risk factor.

Table 15.3 Research Question about Financial Risks and Related Hypotheses Results.

15.4.4 Occupant Dissatisfaction Emerging Risks

The Indicators of this group are the emerging risks that have a direct correlation to the POE factors, which play a vital role in the occupant requirements in the internal environment of buildings and real estate. Occupant dissatisfaction risks within buildings and real estate are centred on occupants' comfort, satisfaction and well-being, such as thermal discomfort (Roaf *et al*., 2009; Capon and Oakley, 2012), health risks due to heat waves (Garvin *et al*., 1998; Ackerman and Stanton, 2006; Wilby, 2007) and possible litigation from occupants (Clark, 2003; Land Use Consultants, 2006; Lord *et al*., 2012). Moreover, the analysis results of the findings have confirmed this statement, as presented in Chapter 12, whilst no significant differences have been established between the groups of respondent. This agreement could be due to the fact that the comfort and safety of occupants are highly important for professionals and practitioners in different sectors and organisations, and should be achieved at higher level in order to meet other goals from property, such as occupants' productivity, whilst avoiding reputation risks.

Moreover, as presented in the results section, there are two risks stemming from this emerging risks cluster, as observed amongst the top concerns across all respondents in terms of the likelihood of occurrence and the high expectation that they will occur in a timescale of 0–5 years. These factors are **O1** and **O2**: **O1** is related to internal environment comfort, which will result in the emergence of **O2**, which is related to the loss of occupant or employee productivity due to thermal discomfort. Clearly, there is a strong correlation between these two emerging risks as the occurrence of **O1** will result in and help in the emergence of **O2**. Furthermore, the literature review declares that the indoor environment within buildings and real estate is essential and plays a vital role in successful building management and the comfort of occupants or employees. This is detailed in Leaman and Bordass (2005) and Seppanen *et al.*, (2004). This evidence confirms that there is the perception of such emerging risks, and that there is practical importance in managing buildings and real estate whilst avoiding further risks, such as reducing the usability of property and the appearance of litigation risks. It is also important to consider the indoor environment within buildings and real estate—especially heat waves and changing temperature—which is the main driver for the emergence of occupant dissatisfaction risks.

15.4.5 Liability and Responsibility Emerging Risks

This emerging risks cluster is related to the responsibility of professionals at all levels, such as designers, constructors, advisors, owners and insurers in the building sector, specifically concerning their liability towards buildings and real estate that are under their management or occupied through them.

According to the analysis of the survey findings, the respondents shared almost the same concerns regarding the potential occurrence of these emerging risks, which have been observed as very low concerns in terms of both the likelihood of occurrence and the timescale of occurrence. Moreover, the data analysis for the findings indicates that many of the respondents (around 50%) expected that all of the identified liability and responsibility emerging risks would emerge after 10 years. The reason behind this is that the professionals in the building sector pay more attention and considerations to the direct emerging risks, such as physical and operational risks, the emergence of which necessitate the professionals' responsibility and facing the risk of litigation as liability and responsibility-emerging risks, which take place as indirect risks from CCS.

Moreover, there is the absence of organised and clear regulations in terms of this kind of potential risk emerging from climate change scenarios. This view has been supported by Griffiths and Smith (2011); Faure and Peeters (2012), who indicate that, recently, the mechanisms of liability towards climate change risks have not been formed. Therefore, determining the probability of occurrence of such emerging risks and their timescales forms the basis in the building sector—specifically for professionals and practitioners, such as designers, architectures, owners, managers and other professionals in the building sector. Additionally, it might be very useful to determine the responsibility and liability of each professional role in the building sector in relation to climate change risks in an effort to assist in adopting or following the correct strategy, which would ultimately help in dealing with challenges and avoiding the impacts from such emerging risks. Establishing the responsibilities and liabilities of each professional in the building sector will result in buildings of greater resilience that are able to cope with or adapt to the potential risks of CCS, especially in new asset projects, starting from the design stage through to the operating and occupying phase.

15.4.6 Reputational Emerging Risks

The emerging risk factors within this group are those related to the negative effects impacting the reputation of organisations or institutions throughout the impacts and damages of risks emerging from climate change patterns on such assets. The previous studies and researches indicate that the buildings and real estate impacted from CCS will suffer from reputational risks as a result of their mismanagement of such emerging risks or the failure to adapt their property. These studies include those by Ross (2005); Kwan (2009); Knobloch and Leurig (2010); St *et al.*, (2010).

This view is supported by the majority of respondents, where approximately 30% and more expect that most reputational risks (10 of 15 factors) might arise within the timescale of 5–10 years. The most important risk factor is **R13**, which is increased carbon emissions, with 57.5% of the respondents holding the view that this would occur in the next 5 years, with approximately 54.6% putting R11—namely related to the negative impact on organisations' brand and reputation—at the lowest important emerging risk factor in this group.

Furthermore, the results of the data finding analysis indicate that there are clear concerns about these types of emerging risk across all groups of respondent. For instance, **R9**, **R13** and **R14** are reputational emerging risks related to an increased possibility of liability risks, increased carbon emissions and increased level of staff and employee stress, respectively, as observed in the list of the top 30 ranked risks. This is evidence that the respondents from different experiences at different organisations or sectors have an obvious concern with the appearance of bad reputation drivers, such as these emerging risks. The significant difference in regards to this cluster of emerging risks is explained in Table 15.4 below. Moreover, as discussed in both the literature review and result sections, the emergence of reputational risks is based on the appearance and frequency of other emerging risks. Ross (2005), supports this view by indicating that the lack and failure of property in terms of the successful performance of their design and operational roles is due to the impacts of climate change patterns; leading to the emergence of reputational risks. However, the ideal management and effective operation processes within buildings and real estate in light of climate change scenario considerations include adapting to and coping with potential risks emerging from CCS; these greatly help to avoid reputational risks—and even will result in a positive reputation for the organisation or sector.

Research Question	Is there a significant difference between the groups of respondents regarding the likelihood occurrence of reputational emerging risks that were identified based on their professional role and type of their organisation?
Hypothesis	*Ha_0 ($p > 0.05$): there is no significant difference between respondents in terms of the rating for the likelihood of the occurrence of risks emerging from climate change.*
Results	- The result of data analysis through one way ANOVA indicated that there were significant differences between public and other type of organisations on one reputational risk R14 - Also there were significant differences between facility managers and risk managers on two reputational risks namely R4 & R13 based on its occurrence timescale
Researchers' Observation	• The emerging risks and impacts occur from different CCS lead to increase the reputational risks and result in bad reputation. • The public sector, in particular more worried about the negative impacts on staff (R14) due to the multiplicity of its buildings, real estate and services that directly dependent on the performance and productivity of their employee. • The emergence of reputational risk factors are strongly related to other cluster of emerging risks from CCS. • The consideration of such risks is vary on the basis of different roles of professional practitioners in the building sector, this is unacceptable; Where the deal and cope with all emerging risks of CCS leads to avoid facing reputational risks and this is the responsibility of all professional roles while these risks are overlapping with each other.
Conclusion	The null hypotheses *Ha_0* was rejected for this reputational emerging risk factor.

Table 15.4 Research Question about Reputational Risks and Related Hypotheses Results.

15.4.7 Regulatory Emerging Risks

In the building sector, there are numerous claims relating to the presence of regulations regarding potential risks emerging from CCS on buildings and real estate; this will positively result in avoiding or adapting property in line with such risks (Lorenzonia *et al.*, 2007; Kwan, 2009; CCRA, 2012). However, the hardness of such regulations, especially with regard to floods and emissions of GHG, might constitute a source of risk and threat to the building sector, adversely affecting the various stages of buildings and real estate, such as design, operation and maintenance, as well as the availability of resources, leading to finding alternative sources. Moreover, the result of the findings analysis highlights such threats and concerns in the building sector as the respondents ranked five out of seven identified emerging regulation risks in the first 30 top indicators. Additionally, Table 15.5 explains the significant differences between respondents, as based on their professional roles in regards to regulation emerging risks; however, the data shows that many respondents (55.80%) claim that the RE7, which is uncertainty about legislation on CC, would arise within the next five years. This obvious concern amongst respondents is supported by other studies, such as that carried out by Knobloch and Leurig (2010), who found that the regulation risks received high concern amongst 74.3% of the study respondents. The implication of this regulation risk reaches each level of a building's lifecycle, such as design, operation and management of assets, and the implication might be limited in random and non-regulated decision-making, especially with regard to the risks of climate change on buildings and real estate.

Clearly, it is useful to state here that this concern relating to regulation risks is supposed to be a strong motivation for all practitioners in the building sector, such as designers, architects, constructors, owners and managers, in regard to the application of solutions and strategies that help assets to avoid or cope with potential risks emerging from CCS. Furthermore, this makes buildings and real estate more resilient in terms of facing the regulations related to the risks of climate change, which could be enacted by legislators and decision-makers outside of the building sector, such as governments and organisations or institutions of environmental protection.

Research Question	Is there a significant difference between the groups of respondents regarding the likelihood occurrence of regulation emerging risks that were identified based on their professional role and type of their organisation?
Hypothesis	*Ha_0 ($p > 0.05$): there is no significant difference between respondents in terms of the rating for the likelihood of the occurrence of risks emerging from climate change.*
Results	- The ANOVA results indicated that there were significant differences between professional roles on four of reputational risks RE3, RE4, RE6 & RE7.
Researchers' Observation	• The other professionals such as owners, advisors and environmental managers are more concern and worried about the likelihood occurrence of regulation risks. • Public and private sector have exactly same view (8th in their ranked list) about RE7, which about the uncertainty of legislation related to emerging risks of CCS. This illustrate that they highly expected the existence of new regulations or develop existing regulation but with absence of clarity of its concept and practical system especially with regard to buildings and real estate. • This perhaps gives them an important steer towards the cautious about the stringent of these climatic regulations.
Conclusion	The null hypotheses *Ha_0* was rejected for this regulation emerging risk factor.

Table 15.5 Research Question about Regulatory Risks and Related Hypotheses Results

15.5 Climate Change Risk Management Factors

This research project identifies and describes a group of CC risk management factors that building officials and practitioners may use in the practice of managing the risks emerging from CCS, as well as adapting and mitigating buildings and real estate in line with such emerging risks—especially amongst existing premises. The core behind adopting these

CCRM strategies and plans is to successfully manage the risks emerging from CCS in an effective and practical way (Lisø, 2006; CCRA, 2012). Several studies and researchers have declared that the CCRM approaches are still new knowledge (Knobloch and Leurig, 2010; Hjerpe and Glaas, 2012; Travis, 2014); this statement has been confirmed by the respondents as half of the identified CCRM factors (24 factor) are not adopted and applied by more than 50% of the respondents' organisations or institutions. Whilst it was observed that approximately 19 out of 24 CCRM factors were considered by the respondents as effective to very effective strategies in relation to managing and controlling emerging climate change risks, the **RM20**—namely strategy to improve energy efficiency—is recognised as the most effective CCRM factor; in second place is **RM17**, which is concerned with plans to improve equipment to reduce emissions, as around 47.4% and 43.6% of the respondents, respectively, considered them very effective factors, adopted by approximately more than 50% of the respondents' organisations and institutions. In addition, the lowest effective CCRM strategy is **RM10**, namely financial stress emergency plans. Moreover, according to the data findings analysis, there is obvious concern regarding the importance and effectiveness of these CCRM factors across all groups of respondent, as based on the type of employee in organisations, with very little difference in only one CCRM factor, namely **RM22**, as explained in Table 15.6 below.

Research Question	Is there a significant difference between the groups of respondents regarding the effectiveness of climate change risk management factor that were identified based on their professional role and type of their organisation?
Hypothesis	*Hc_0 ($p > 0.05$): there is no significant difference amongst the respondents in terms of the level of effectiveness of CCRM factors.*
Results	- The ANOVA results indicated that there were significant differences between professional roles on five of CCRM factors; namely RM1, RM2, RM8, RM9 & RM18. - Also there were significant differences between Public and private organisations in terms of RM22.
Researchers' Observation	• The CCRM might be a basic for managing the emerging risks from CCS within the building sector. • Risk managers have more endorsement of the importance and effectiveness of the CCRM strategies and plans due to their role in the management and control the emerging risks from CCS. • Participants in various specialisations agreed on the effectiveness of strategy related to equipment development to reduce emissions (MR17); As well as on other that associated with the development of energy efficiency (RM20), which is also reflected positively in reducing emissions.
Conclusion	The null hypotheses Hc_0 was rejected for these CCRM factors.

Table 15.6 Research Question about CCRM Factors and related Hypotheses Results.

In addition, these CCRM factors were tested in this research project in terms of their effectiveness as strategies, plans and tools to avoid or cope with the risks emerging from CCS on the building sector. Furthermore, the CCRM strategies and planning are therefore concerned with the implementation and post-implementation issues, reinforcing the notion of risks emerging from CCS at different stages and phases of the buildings and real estate lifecycle, whilst also changing the importance of risk between risk assessment and risk impacts and damages. These CCRM strategies and plans impact the technical system (such as maintenance, operation process and energy use) and non-technical system, such as through planning for mitigation and adaptation, the availability of required resources, and maintaining financial and marketing positions.

15.6 Implications

The literature review highlighted that the previous research and studies on risks emerging from CCS on buildings and real estate are almost non-existent (Crawley, 2003; Hacker *et al.*, 2005; Hunt and Watkiss, 2011), as well as the timeframe of their occurrence. However, existing studies and research focus more so on the potential physical risks stemming from climate change patterns, as highlighted by various scholars (Garvin *et al.*, 1998; Wingfield *et al.*, 2005; Ross *et al.*, 2007; Szyman and McNamara, 2008; Horváth and Pálvölgyi, 2011; Hallett, 2013). The reason behind this is that previous research and studies, such as that by Knobloch and Leurig (2010), classified the potential risks of CCS according to several dimensions, such as the type of damage, the direct influence on property and its elements, as well as common characteristics with other types of risk. Furthermore, previous studies lacked a link with the emergence of risks on property in a temporal scale, which helps in organising and tabulating the stages process and activities in the building sector—especially with regard to maintenance, operation and the availability of resources—or even the search for alternative sources.

This research fills this gap by classifying the potential risks emerging from climate change patterns into practical organised maps. This clustering is based on several determinants, such as risk types, including the impact levels of these risks, and who is most vulnerable to such risks, i.e. buildings themselves and their elements, or their occupants and the professionals involved in the building sector. This classification could lead to enhancing and maximising the successful management and controlling of these risks in certain timeframes, thus avoiding their impacts and damage on property, whilst also facilitating the adapting and mitigation of buildings and real estate to deal with future CCS. Furthermore, this classification and its implementation could assist in achieving and enhancing the performance of buildings and real estate, whilst also protecting occupants and controlling operational leaks, such as energy sources, and clarifying the image in terms of responsibility for these emerging risks at all levels in the building sector, such as practitioners and professionals, occupants and employees, or even insurer companies.

One further important finding achieved through this research project compared to previous researches and studies is the evidence of the perception of CCRM strategies and planning in terms of their effectiveness. CCRM factors are no less important than identifying and assessing the risks emerging from CCS and their timescale of emergence as CCRM strategies play a pivotal role in managing and controlling these potential risks through systemic methods, especially for mangers, owners, designers, constructors and advisors in the building sector. In addition, it facilitates their mission and duty in dealing with such risks and also in terms of protecting them from legal issues due to failures in dealing with such arising risks.

This research project provides a starting point for wider horizons that are still require further investigation on both the risks emerging from CCS and the occurrence timescale of their emergence—especially across different types of building and real estate—demonstrating them in parallel with potential conditions of climate change on the building sector in different areas and regions. Moreover, there is still a lack of research on CCRM approaches and strategies, which might be considered a road map for facing and dealing with these different risks emerging from climate change patterns.

It is valuable to divide the main implications in the following points:

- From design and specification perspective, considering the potential emerging risks and impacts from CCS and their occurrence timescale by architects and designers will result in ensuring the longevity of assets at an acceptable level of performance. The ability to adapt to such risks helps to fulfil the main goals of buildings' design and construction. Designers should be able to devise design strategies that mitigate or avoid the impact of physical risks, and designers should be able to specify materials that are durable and resilient to climate change scenarios. In addition, this consideration leads to the generation of buildings and real estate that are highly able to cope with such emerging risks.

- From a construction perspective, consideration of various risks emerging from CCS during the construction stage of a building's lifecycle will decrease the period of downtime due to these risks and accordingly will enhance the completion of the project, including construction activities, as well as smooth and easy transition from one stage to another of the key stages of the construction processes. Importantly, adaptive construction strategies must be incorporated into future buildings in order to develop resilience against some of the risks discovered in this thesis.

- From the perspective of buildings management, identifying and enhancing awareness of the risks emerging from CCS would increase the chances of successful management of buildings in terms of the level of performance, property protection and providing a comfortable and safe environment for occupants, which will lead to achieving satisfaction. Moreover, consideration to these risks will assist professionals to perform their duties and technical functions; these will result in maximising the chances of increased reputation for both assets and the management group.

- From a finance and costing perspective, in relation to buildings and real estate and operating, both considering and coping with these risks emerging from CCP, play a pivotal role in avoiding both more financial losses due to the damages of these emerging risks and the needs for retrofits and repairs, including replacements, which sometimes might prove very costly. Moreover, taking into account these emerging risks during the operation phase of property assists in avoiding disruption and decreasing necessary maintenance, which could result in reduced financial losses.

- From an environmental perspective, considering the risks emerging from CCS in the building sector in both practical and effective ways will result in protecting the environment from these risks and their related actions, whilst also reducing the emissions of GHGs from assets and generating buildings and real estate that are environmentally friendly—not only in themselves but also in terms of the materials and components used.

- From a research perspective, this research is the first study combining both the potential emerging risks and their emergence timeframe whilst uncovering the main strategies of managing and controlling these emerging risks. Hence, this study could act as a cornerstone for more researches and studies in this field, which will result in raised innovations in the building sector in different ways, such as design, construction, management and operation.

15.7 Summary of this Chapter

This research project described the dimensions of the risks arising from CCS on different orientations, such as in technical and non-technical domains, within the building sector, where such risks are associated with changes in various CCS. The level of agreement amongst participants in the study, in terms of the probability of emergence of climate change risks, along with the occurrence timescale, gives implications as to the level of concern in the building sector from these emerging risks and impacts. Moreover, the differences in the perceptions of these risks were based on the type of organisation or sector and the professional roles of the participants, which provide an idea for how to deal and cope with these risks arising from CCS.

The research presents a list of strategies and factors considered as tools to assist practitioners and professionals in the management of such risks and adaptation to deal with emerging risks. This also leads to devising positive results, which help in reaching the maximum level of operating buildings and real estate in ways that are both safe and sound for professionals and occupants, and the environment alike.

CHAPTER 16: SUMMARY AND CONCLUSION

16.1 Introduction

Despite the presence of concerns and fear stemming from the emergence of risks from CCS on buildings and real estate and the extent of their impact on the operational and organisational processes in the buildings sector, there remains a lack of organisation in previous studies, which suggests failure in organising and clarifying these emerging risks from several binoculars. This research project focuses on the risks emerging from climate change patterns and the timeframe of occurrence through the extraction, identification and assembling of them in consistent and practical groups so as to facilitate the return to and adequate management by practitioners and professionals, even preventing the building of future research and studies for researchers and other parties interested in the buildings sector.

In this chapter of the research project, a review summary of this research is provided, which includes the contributions of this study and the limitations on the research project, as well as the derived recommendations and suggestions for further areas of research and study.

16.2 Summary

The different scenarios of climate change, such as floods, temperature change and storms, are considered the main drivers influencing the building sector at different levels and dimensions. These impacts directly and indirectly negatively impact the systems and strategies in the building sector, which are associated with the performance and operation of buildings and real estate; therefore, understanding how and when the emergence of these climatic risks is pivotal in dealing with these risks and applying the adaptation and mitigation strategies so as to minimise the effects and damages. Moreover, the fact that identifying and analysing risks play a crucial role in the process of managing and controlling risks; hence, the main focus in this study was centred on uncovering the potential risks arising from climate change scenarios on buildings and real estate, along with identifying the basic factors and tools in the administration of such emerging risks.

Throughout the multiple chapters of this research project, the extent to which the various scenarios of climate change can affect the building sector through disruption buildings and real estate has been discussed, including the emergence of impacts and damages that affect the functional and design roles' performance of buildings and real estate, as well as the impacts that can be affect the occupants. Moreover, this study attempts to establish the relationship between the building sector and the legal aspects by identifying the regulations and reputational risks the decision-makers, stakeholders and practitioners in the building to become exposed.

One of the main goals of this research projects is to find, classify and develop these emerging risks in a scientific and practical manner, which can then reduce the negative effects and damages stemming from such risks, whilst also increasing the awareness and knowledge of the professionals and stakeholders in the building sector concerning such risks emerging from CCS.

Based on the investigation of these emerging risks, the research devises a range of interactive strategies that fall under the climate change risk management, which are considered assistant tools for professionals in the building sector—managers, owners and advisors, in particular.

This study project is based on a the multi-methodological approach, which includes a variety of resources, such as theories, previous researches and studies, along with the extensive experience of the supervisor of this research project and the researcher's own personal knowledge and experience.

16.3 Conclusion

This research has covered all objectives that have been drawn in chapter one which assist to achieved the main aim of this study. Clearly, the objectives of this research can be summarised into the following points:

The first objective centred on discovering the climate change and the possible scenarios as well as explore the different views about its threat on the building sector. This objective was achieved through a comprehensive literature review and considering previous researches and studies in this area. The main findings were as follow:

- There are a clear concern about the CC and its risks and impacts.
- The relationship between buildings and the climate change is still in its infancy.
- There is no clear classification for risks that emerging from CCS on buildings and real estate.

This research has provided an understanding of the concepts and association between buildings and the emerging climate change risks.

The second objective of this research involved the investigation of the emerging risks arising from CCS. This has been accomplished by conducting the following tasks:

- Conducted a systematic review in order to find out the CCR that affect buildings and real estate.
- Develop a comprehensive list of CCR factors based on the identified correlation between CCS and the building sector.
- Transformed these CCR into practical classification.

The achievement from this objective were identifying 112 CCRs which have been grouped into seven main clusters covering the emerging risks from CCS. These risk factors represent the direct and indirect risks on buildings and real estate as well as on related stakeholders such as occupants or practitioners within the building sector.

The third objective focussed on reviling the most effective climate change risk management (CCRM) factors in relation to managing and controlling such emerging risks. This has been identified through considering the emerging CCR and find out the possible solution and strategies that assist in mitigate and adapt the risks arising from CCS. The outcomes for this objective were establishing a CCRM factors list that consist of 24 factors that play vital role in mitigation and adaptation buildings in dealing with CCR.

The fourth objective was to design and carry out the quantitative online survey along with reporting the statistical analysis findings (summary can be found in tables 13.15 and 13.16). In short, the main outcomes from the questionnaire were as below:

- The operational risks were found to be the most important group of risks, based on the respondents' view in terms of both the likelihood of occurrence and the timescale of occurrence. However, the liability and responsibility emerging risks have been perceived very low concerns.
- The majority of the organisations and sectors of the respondents are considering the CCRM as important and effective strategies; however, more than 50% of the respondents do not adopt or implement such CCRM strategies.
- There was clear agreement between the groups of respondents in terms of the likelihood occurrence of emerging CCR.
- There was a significant difference observed in 13 out of 112 factors based on the professional role ranking in terms of likelihood occurrence of emerging CCR;

however, there was no significant differences concerning the time scale of arising such risks.

The last objective of this research project was to explore the emergence timescale of risks stemming from CCS. To achieve this point, the question was divided into four categories of time horizon, in effort to find out the occurrence time scale of the identified CCR. The main findings were outlined below:

- Based on the type of both organisations and professional roles, there were noticeable agreement in terms of the occurrence time frame for the emerging risks; however, only two factors found to be having a significant difference in this regard, namely OP6 and F16, based on the type of organisations.
- Around one third of the physical emerging risks occur in short term (0-5 years) time scale.
- Almost half of the operational risks will arise their impact on buildings and real estate in very short time scale.

Overall, this research project studied the risks emerging from all related aspects to buildings and real estate, such as physical, operational, legal and financial, as well as health and well-being. Thus, it could be as a semi-comprehensive reference to climatic emerging risks in the building sector, or even as a starting point for future researches and studies in this aspect.

16.4 Research Contributions

The main contribution of this research project is establishing and developing a conceptual clustering of the potential risks emerging from CCS, which can assist professionals in the building sector in the management and development of strategies to cope with these emerging risks. The main contributions of this study project are as below:

- This is the first study combining the risks emerging from CCS with their occurrence timescale.
- This study has been developed based on a comprehensive literature review, including the discussion of previous studies and researches on the potential risks from climate change patterns on the building sector.
- As far as the author is aware, this is the first study mapping out the climate change scenarios to building assets risks with emergence timeframe and link them to the suitable CCRM strategies and planning.

- Clustering these emerging risks in a practical classification will be easier to use in dealing with such emerging risks.
- This classification helps management and stakeholders in the building sector to identify the risks arising from CCS prior to their occurrence in order to take measures and strategies that assist their buildings and real estate in facing and coping with these risks in different circumstances, and also in protecting occupants in an effective and systematic ways.
- The classification of these identified emerging risks could assist professionals in the building sector, such as architects, designers, owners, advisors, investor and insurers, in decision-making concerning their assets so as to achieve both the best and right decisions of solutions or CCRM strategies for these emerging risks at an appropriate time.

Other contributions of the research are presented as follows:

- The extraction of 112 risk factors emerging from CCS that have potential impacts and damages on buildings and real estate.
- Clustering these emerging risks (112) into practical classifications (seven cluster) based on their types, drivers, impacts and damages.
- Defining the type of each cluster from the building sector perspective.
- Identifying and extracting 24 CCRM factor as strategies and planning tools to assist the managers and other responsible professionals in order to manage and control of such risks.

16.5 Research Limitations

It is very rare to find an ideal and integrated study or even classification that covers all relevant aspects of the potential risks emerging from climate change scenarios in the building sector. Although this conceptual classification in this research covers 136 factors for both risks emerging from CCS and CCRM strategies, there remain various points of weakness that could improve this classification. Hence, the limitations in this research were as follows:

16.5.1 General limitations:

- This classification of emerging risks is designed to comply with all types of building and real estate; it is advisable that a separate classification be developed for each type of building, such as hospitals, education buildings and office buildings, etc.

- The clustering of the emerging risks arising from CCS in seven groups were based on the researcher's own interpretations, based on the theoretical concept of each group and its determinants related to buildings and real estate. However, there may be some factors not covered by this study.

16.5.2 Methodology limitation:

- The method were adopted in this study is online survey in order to collect more data in specific time from professionals and practitioners in different sectors and organisations across the UK; however other approaches such as case studies and interviews with stakeholders and involved parties in this field will improve such study.

16.5.3 Findings limitations:

- Participants in this study were from one country (the UK) and chosen based on their professional roles in specific sectors and organisations such as universities, hospitals and housing institutions. Therefore, it is advisable that future work in this area can be carried out in different ways such as comparing more countries in order to extend the knowledge and find out more CCR factors.
- The method were adopted in order to collect data was online survey which limited the findings. However, it was the best way to cover all regions of the UK; in future, it could be improved by considering more approaches in data collection phase such as interview with professionals and practitioners or site visit.

16.6 Recommendations for Areas of Further Research

Based on the research and conclusions addressed, the following point out the suggestions and recommendation for further studies and researches in this field:

- Further investigation and gathering information more broadly on a global level, and comparing the results with each other, which will lead to achieve an ideal approach or an integrated model for the risks emerging from CCS on the building sector.
- This study has shown that some of the key aspects of the classification are almost non-existent studies and researches, such as regulations and liability risks especially with regard to the building sector. Hence, further research is required in order to develop a holistic cluster and guidance for these groups that associated with the impacts of CCS.

- As presented earlier on in this research, the occupant and employee within buildings and real estate are exposed to the risks emerging from CCS in several ways; hence, it would be useful to investigate the responses of stakeholders (occupant and employee) towards these emerging risks within affected property.
- From the perspective of management concerning emerging risks, the CCRM strategies and planning identified in this study could be tested or applied, which would assist and help in establishing the ideal strategies and identifying the difference of the magnitude of these emerging risks prior to and after the application of these CCRM strategies and plans.

This research embraces just one part of reality and achieves exact results, which warranted huge efforts. It is hoped that this research project will be used by researchers and interested parties as a basis and cornerstone for making greater attempts to protect, adapt and mitigate buildings and real estate from the impacts and threats of climate change scenarios.

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Appendix A: Questionnaire

Dear ……………..,

Climate change will have a huge impact on a variety of complex human decisions that affect natural systems, social systems and human-made networks. Understanding how and when climate change risk related information is formed, disseminated and consumed is the key to optimal timing and design of policies, systems and procedures that affect all aspects of everyday life. Your input can help us to detect emerging risks associated with building assets management as a consequence of climate change scenarios. We estimate that it will take you approximately 10-15 minutes to complete the survey.

All individual responses will remain confidential and study data will be amalgamated and analysed as a whole. Results will be reported in summary form to protect confidentiality. However, if you have any questions or concerns about the questionnaire or about participating in this research, you may contact me on 07412227333 (engamyz@liv.ac.uk). Alternatively, you may communicate my supervisor, Dr Boussabaine on 01517942619 (halim@liv.ac.uk).

Please also feel free to forward URL of the web survey to relevant built environment stakeholders.

Simply click on the link below, or cut and paste the entire URL into your browser to access the survey:

http://survey.liv.ac.uk/Emerging-Risks-of-Climate-Change

We would grateful appreciate your response by no later than one week.

Thank you for your time and support and I look forward to sharing the outcomes of this survey with all of the participants.

Yours faithfully

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1A Q: Which of the following risks do you think will have an impact on your buildings/real estate and in what time frame do you think their impact may emerge*

	*Please check one box from the likely impact and one from the occurrence time frame	Likelihood impact					Occurrence time-frame			
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely	0-5 Years	5-10 Years	Over 10 Years	Not at all
Physical Emerging Risks	Rapid asset deterioration									
	Potential for increased odour problems									
	Reduced asset life									
	Disposal of debris including hazardous materials (from windstorms)									
	Increased fire risks									
	Scour to structures (from intense rainfall)									
	Cracking or melting of pavements									
	Cracking of building fabric									
	Potential need for retrofitting mechanical ventilation									
	Increased capital expenditures									
	Reliability of mechanical and electrical services in buildings									
	Increasing subsidence and heave movement									
	Damage to building foundation due to subsidence and heave movement									
	Damage to building facades due to subsidence and heave movement									
	Increasing soil shrinking and swelling									
	Damage to underground services									
	Surface water flooding									
	Groundwater water flooding (from rising groundwater)									
	Water ingress to facades									
	Water ingress to roofs									
	Inundation of basement and ground floor									
	Vulnerability of services and plant									
	Increase in the cost of materials supplies									
	Saline water intrusion									
	Corrosive saline atmospheric exposure									
	Increase of acid rain weathering on building fabric									
	Increase of defective building elements due to unforeseen weather conditions									
	Extreme exposure of building shell to dust									
	Increase of latent defect problems									
	Damage due to high snow load on buildings									
	Damage to building assets from frost/snow									
	Increase of damp, condensation and mould problems in buildings									
	Erosion of historic building fabric									
	Lightning strike damage to buildings during storms									
	Slope instability									
	Insufficient roof drainage in storms									
	Decreased durability and performance of materials									

1B	Q: Which of the following risks do you think will have an impact on your buildings/real estate and in what time frame do you think their impact may emerge*									
*Please check one box from the likely impact and one from the occurrence time frame		Likelihood impact					Occurrence time-frame			
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely	0-5 Years	5-10 Years	Over 10 Years	Not at all
Operational Emerging Risks	Increase in energy use									
	Higher energy prices									
	Increasing water costs									
	Water use restriction									
	Higher costs of repair									
	Increased maintenance regimes									
	Electricity brownouts and blackouts									
	Increased reliance on mechanical cooling									
	More frequent mechanical breakdowns									
	Reduced access to infrastructure									
	Reduced access to facilities									
	Increased downtime									
	Increase in the cost of waste water discharge									
	Temporary closure of facilities									
	Increased costs due to alternative short-term supplies									
	Interruption of supply chain									
	Disruptions of telecommunication services									
	Increased slips and falls									

1C	Q: Which of the following risks do you think will have an impact on your buildings/real estate and in what time frame do you think their impact may emerge*									
*Please check one box from the likely impact and one from the occurrence time frame		Likelihood impact					Occurrence time-frame			
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely	0-5 Years	5-10 Years	Over 10 Years	Not at all
Financail Emerging Risks	Lower profit margins									
	Unable to repay debts									
	Equity growth not realised									
	Increase in administrative expenses									
	Reduced ability to secure funding for adaptation due to negative property valuation									
	Reduced ability to secure funding for refurbishment due to negative property valuation									
	Fall in value of mal-adapted properties									
	Loss of income from properties									
	Businesses become less competitive									
	Properties may not be saleable because of climate change compliance									
	Negative property valuation due to structural damage									
	Negative property valuation due to services damage or compliance with climate change legislation									
	Loss of revenue due to customer behaviour									
	Changing patterns of consumer demand									
	Affordability of property rent/development									
	Increase costs to purchase									
	Increased insurance excess									
	Additional expense in insuring buildings prone to the urban heat island effect									
	Additional expense in insuring buildings in flood risk zones									
	Increases in areas prone to soil heave/shrinkage									
	Un-insurability due to climate change									
	Affordability of property insurance									
	Availability of property insurance									

1D	Q: Which of the following risks do you think will have an impact on your buildings/real estate and in what time frame do you think their impact may emerge*									
	*Please check one box from the likely impact and one from the occurrence time frame	Likelihood impact					Occurrence time-frame			
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely	0-5 Years	5-10 Years	Over 10 Years	Not at all
Occupant dissatisfaction Emerging Risks	Thermal discomfort									
	Loss of productivity									
	Heat related health risks									
	Usability of Buildings become impaired									
	Business continuity impaired									
	Occupant litigation									

1E	Q: Which of the following risks do you think will have an impact on your buildings/real estate and in what time frame do you think their impact may emerge*									
	*Please check one box from the likely impact and one from the occurrence time frame	Likelihood impact					Occurrence time-frame			
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely	0-5 Years	5-10 Years	Over 10 Years	Not at all
Liability & Responsibility Emerging Risks	Increase of recourse action against professional advisors									
	Buildings dangerous to health as a result of high temperature									
	Increase of claims in contract or tort because buildings designed, or operated in a way that has insufficient regard to the reasonably anticipated impacts of climate change									
	Increasing environmental litigation									
	Increasing decommissioning liabilities									
	Professionals (advisers, designers, owners, tenant, insurers) will bear the responsibility of mal-adapted new buildings									

1F

Q: Which of the following risks do you think will have an impact on your buildings/real estate and in what time frame do you think their impact may emerge*

*Please check one box from the likely impact and one from the occurrence time frame

		Likelihood impact					Occurrence time-frame			
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely	0-5 Years	5-10 Years	Over 10 Years	Not at all
Reputational Emerging Risks	Loss of economic benefits									
	Negative impact on corporate social responsibility									
	Market differentiation									
	Loss of organisations' sustainability credential									
	Loss of investors									
	Lower staff retention and productivity due to building usability									
	Higher economic risks									
	Higher legal risks									
	Higher liabilities risks									
	Loss of potential customers due to business interruption									
	Negative impact on organisations' brand and reputation									
	Increased sick days									
	Increased carbon emissions									
	Increased level of staff stress									
	Negative impact on organisations reputation from being seen as a contributor to climate change									

1G

Q: Which of the following risks do you think will have an impact on your buildings/real estate and in what time frame do you think their impact may emerge*

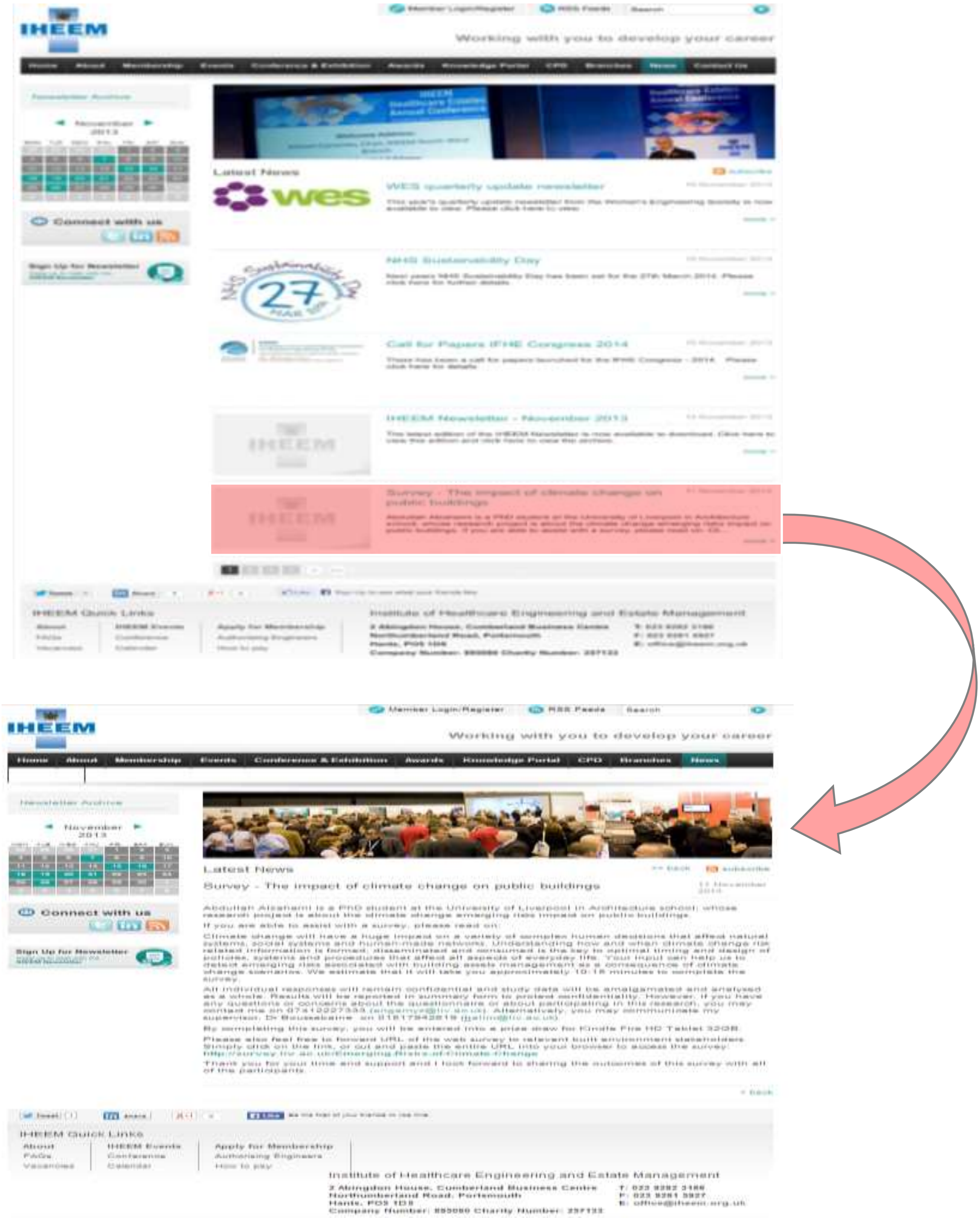
*Please check one box from the likely impact and one from the occurrence time frame

		Likelihood impact					Occurrence time-frame			
		Very Unlikely	Unlikely	Neutral	Likely	Very Likely	0-5 Years	5-10 Years	Over 10 Years	Not at all
Regulation Emerging Risks	Stringent regulation in relation to water stress									
	Stringent regulation in relation to flood stress									
	Stringent regulation in relation to overheating stress									
	Stringent regulation in relation to windstorms stress									
	Strict limits on greenhouse gas emissions									
	mandatory climate change risk-appropriate building regulation									
	Uncertainty of pending legislation on climate change									

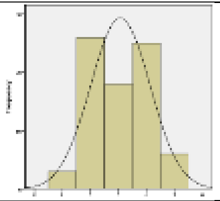
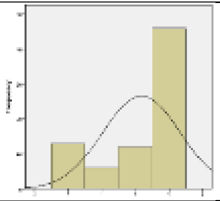
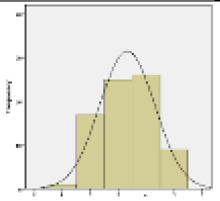
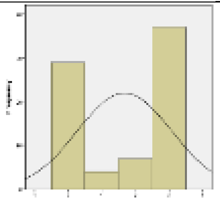
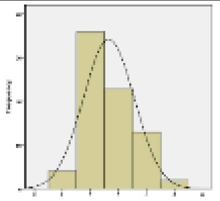
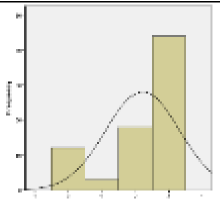
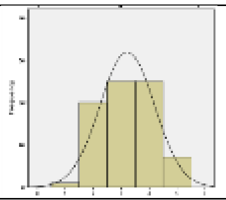
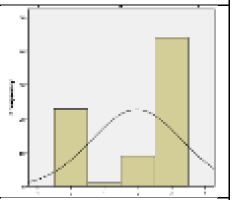
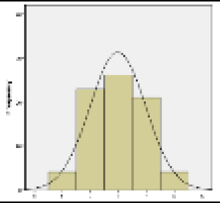
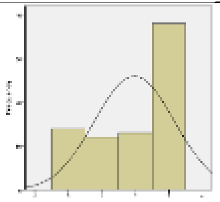
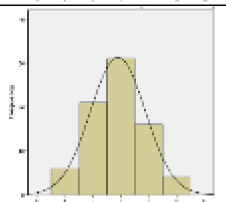
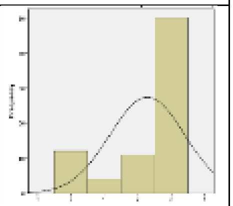
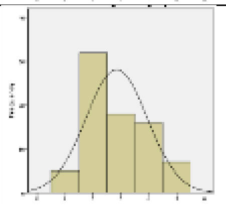
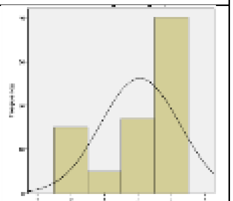
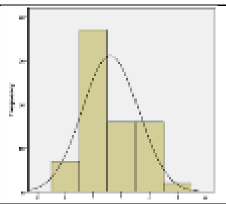
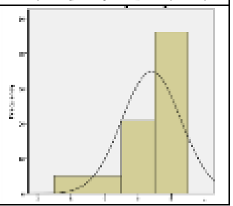
2	Q: In your opinion how effective the following climate change risk mitigating strategies. Please also select strategies used by your organisation*						
	*Please check one box from the effectiveness of the mitigating strategies and one from the usage of the strategies by your organisation	Very Ineffective	Ineffective	Neutral	Effective	Very Effective	**Tick if used by your organisation**
Climate Change Risk Management	Disruption planning						
	Balancing resources						
	Stand-by-preparation						
	Maintenance planning						
	Operations planning						
	Resource planning						
	Maintenance scheduling						
	Adaptation planning						
	Property portfolio climate change risk management						
	Financial stress emergency plans						
	Development of new compliance infrastructure						
	Mitigation plans for disruption to business processes						
	Plans to deal with changes in market demand						
	Mitigation plans for disruption to supply chain						
	Availability of resources						
	FM strategies to improve properties to reduce emissions						
	Plans to improve equipment to reduce emissions						
	Plans to manage water footprint						
	Plans to use adaptation technology						
	Strategy to improve energy efficiency						
	Increasing use of renewable energy						
	Plans to generate renewable energy on site						
	Water management mitigation plans						
	Waste management plans						

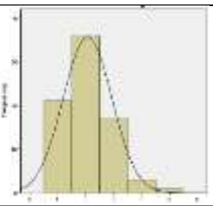
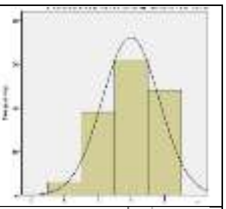
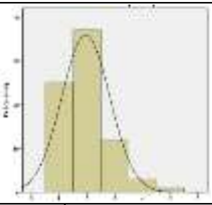
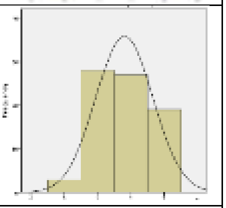
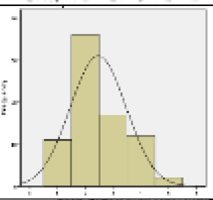
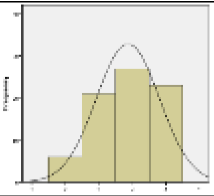
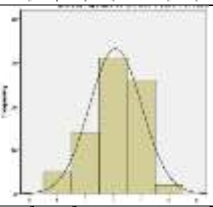
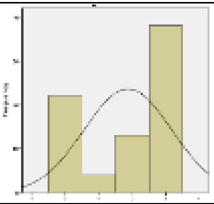
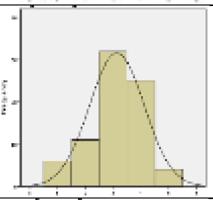
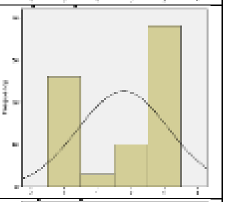
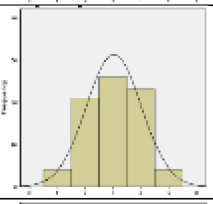
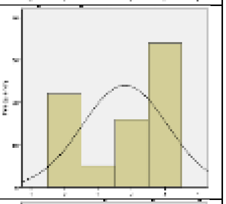
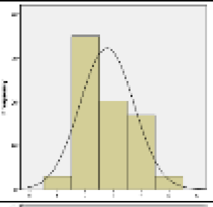
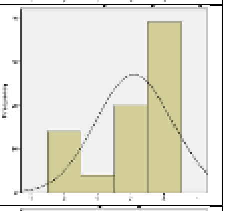
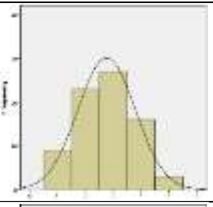
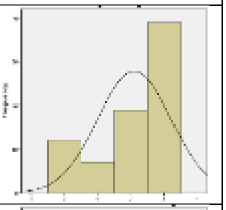
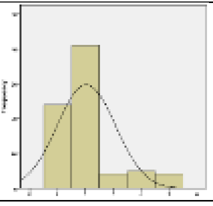
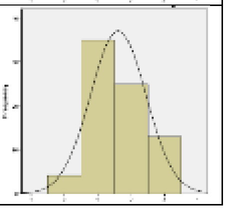
3	General Information of Participants	
3a	**Please select the type of your organisation***	
	( )	Private
	( )	Public
	( )	Charity
	( )	Other, please specify
3b	**Please indicate your role in your organisation***	
	( )	Facility manager
	( )	Real estate’s portfolio manager
	( )	Owner
	( )	Risk manager
	( )	Academic
	( )	Other, please specify
3c	**Does your organisation have expertise in assessing and managing emerging risks from climate change***	
	( )	Yes
	( )	No
3d	**How many buildings your organisation is responsible for***	
	( )	Fewer than 5 buildings
	( )	6-10 buildings
	( )	11-20 buildings
	( )	Over 20 buildings
3e	**To what extend that do you think your building-real estate stock need to be adapted to climate change***	
	( )	Below Average
	( )	Average
	( )	Above Average
	( )	Not at all
3f	**Does your organisation have guidelines for assessing emerging climate change risks***	
	( )	Yes
	( )	No
3g	**In your opinion to what extent your organisation is developing innovative solutions to adapt its building stock to climate change***	
	( )	Below Average
	( )	Average
	( )	Above Average
	( )	Not at all

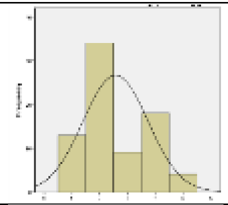
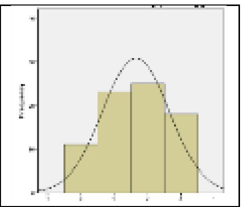
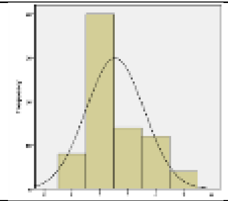
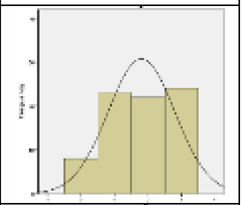
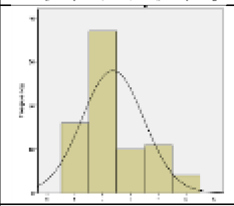
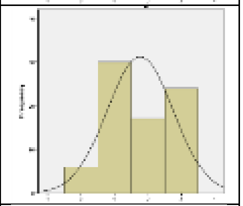
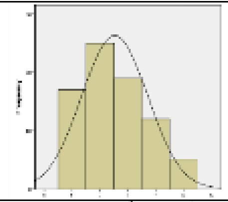
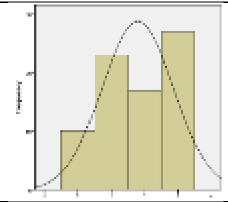
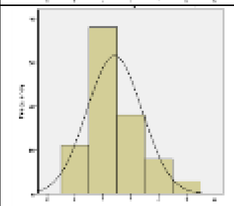
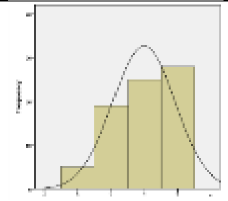
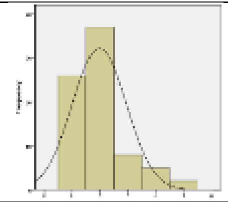
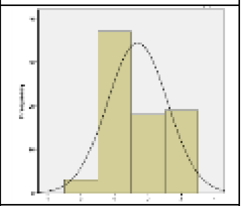
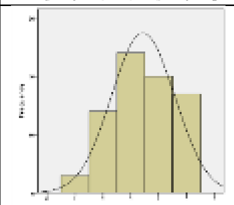
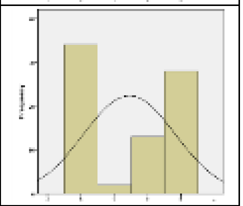
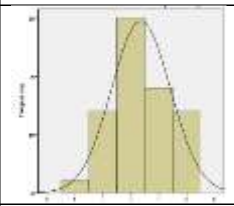
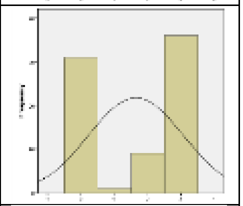
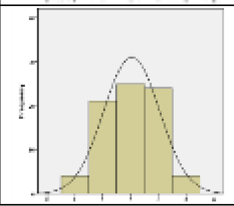
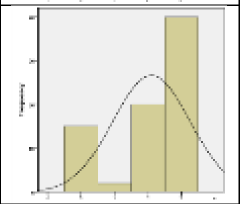
Appendixes B: Published the Questionnaire in IHEEM

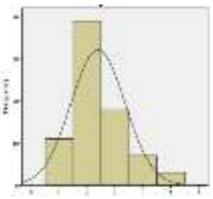
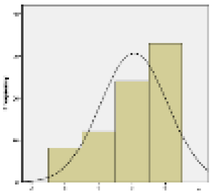
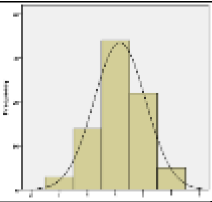
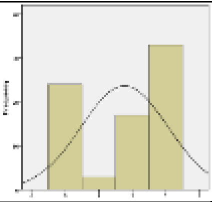
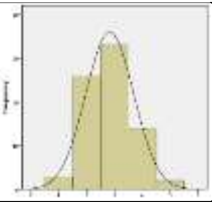
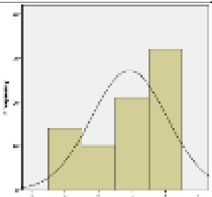
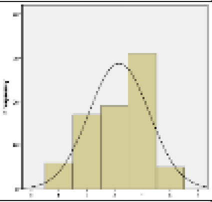
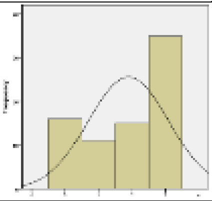
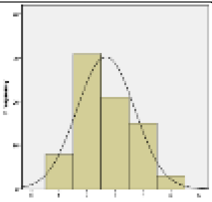
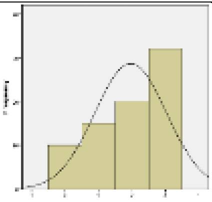
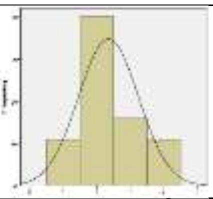
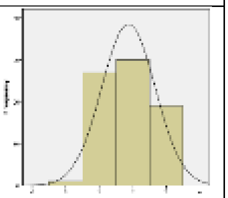
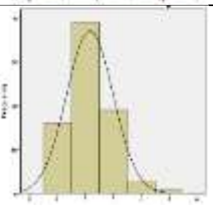
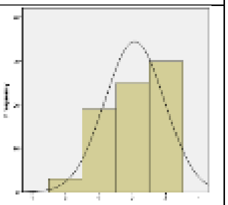
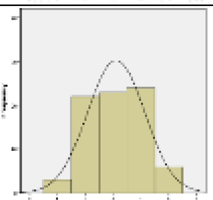
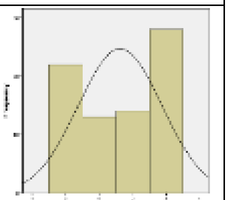
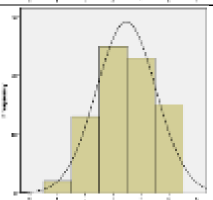
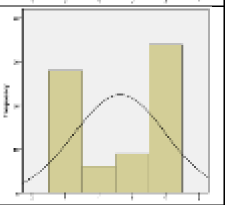


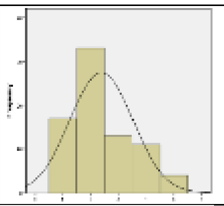
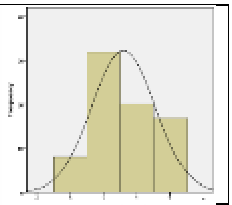
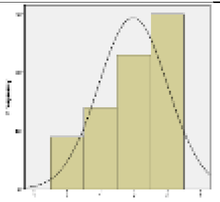
PPENDIX C: Histogram for each emerging risk factors

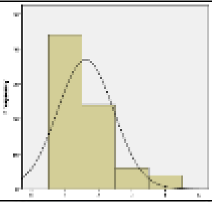
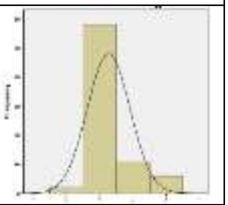
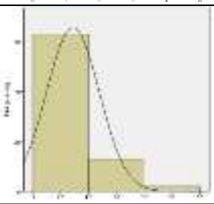
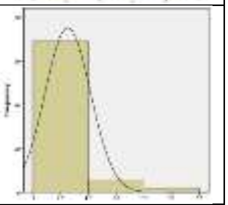
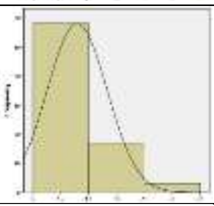
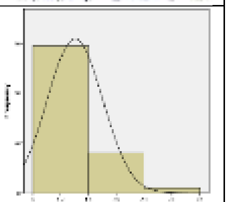
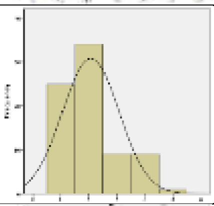
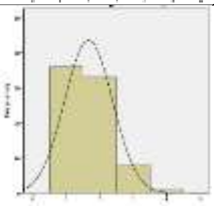
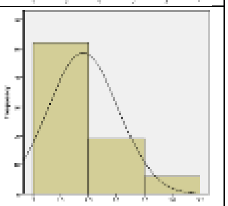
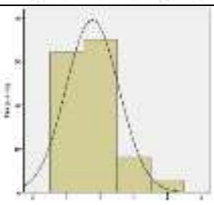
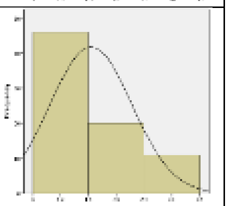
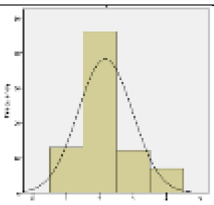
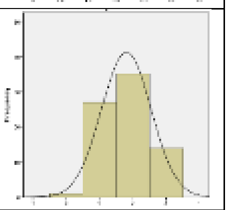
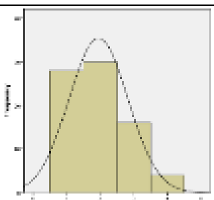
Physical Emerging Risks							
Code	Risk Factors	Likelihood Occurance			Occurance Time scale		
		Mean	S.D	Histogram & Normal Curve	Mean	S.D	Histogram & Normal Curve
PH1	Rapid asset deterioration	3.06	1.06		2.18	1.155	
PH2	Potential for increased odour problems	3.32	.987		1.68	1.400	
PH3	Reduced asset life	2.65	.909		2.22	1.096	
PH4	Disposal of debris including hazardous materials (from windstorms)	3.22	.976		1.96	1.342	
PH5	Increased fire risks	2.97	.993		1.97	1.181	
PH6	Scour to structures (from intense rainfall)	2.88	.993		2.29	1.122	
PH7	Cracking or melting of pavements	2.85	1.10		2.06	1.174	
PH8	Cracking of building fabric	2.60	.998		2.40	.877	

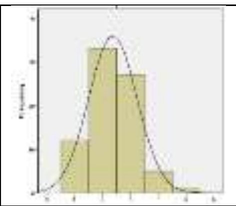
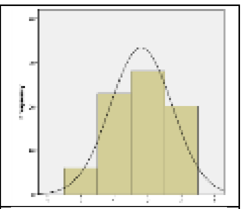
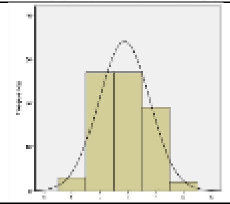
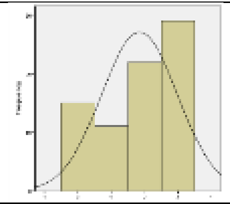
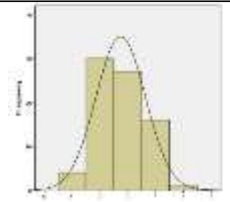
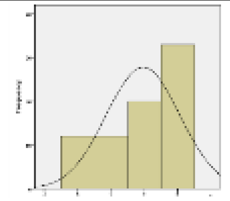
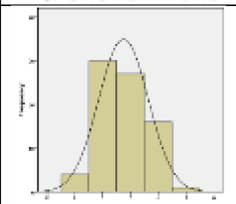
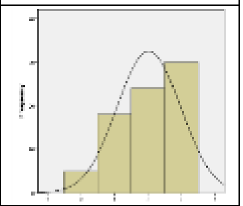
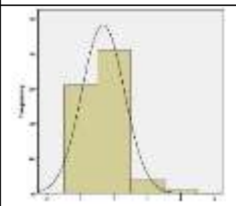
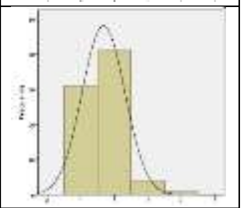
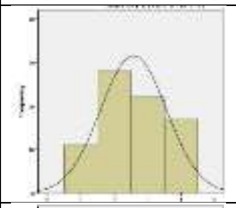
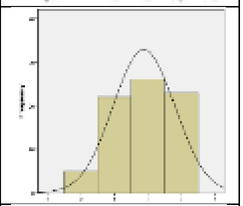
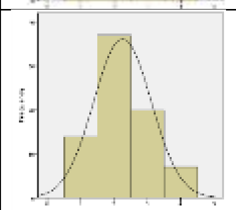
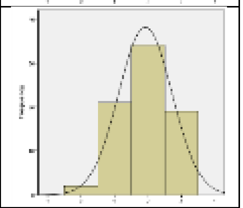
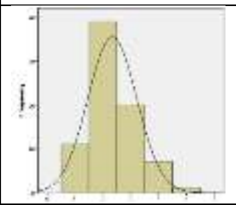
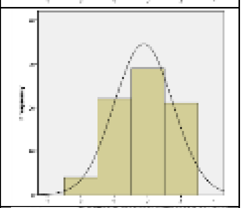
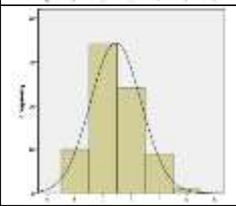
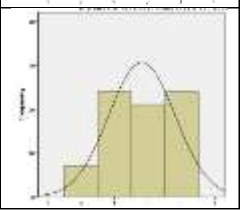
PH9	Potential need for retrofitting mechanical ventilation	2.06	.873		1.99	.851	
PH10	Increased capital expenditures	1.95	.866		1.81	.859	
PH11	Reliability of mechanical and electrical services in buildings	2.46	1.00		1.87	.937	
PH12	Increasing subsidence and heave movement	3.08	.937		1.87	1.301	
PH13	Damage to building foundation due to subsidence and heave movement	3.13	.985		1.78	1.363	
PH14	Damage to building facades due to subsidence and heave movement	3.03	.993		1.81	1.278	
PH15	Increasing soil shrinking and swelling	2.77	.966		2.09	1.138	
PH16	Damage to underground services	2.76	1.03		2.10	1.107	
PH17	Surface water flooding	2.03	1.04		1.61	.830	

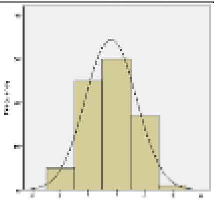
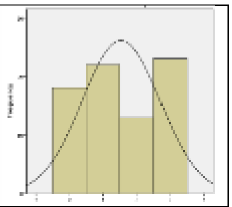
PH18	Groundwater water flooding (from rising groundwater)	2.56	1.16		1.65	.997	
PH19	Water ingress to facades	2.54	1.04		1.81	1.001	
PH20	Water ingress to roofs	2.36	1.11		1.77	.985	
PH21	Inundation of basement and ground floor	2.53	1.18		1.79	1.068	
PH22	Vulnerability of services and plant	2.41	.986		1.99	.939	
PH23	Increase in the cost of materials supplies	1.97	.967		1.69	.892	
PH24	Saline water intrusion	3.44	1.13		1.45	1.372	
PH25	Corrosive saline atmospheric exposure	3.36	1.05		1.65	1.412	
PH26	Increase of acid rain weathering on building fabric	3.04	.999		2.10	1.154	

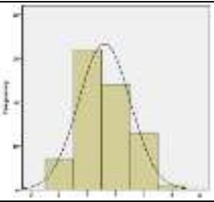
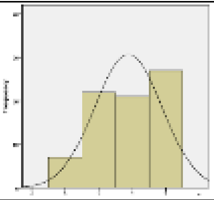
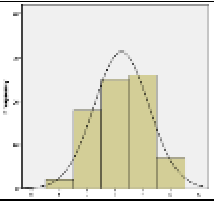
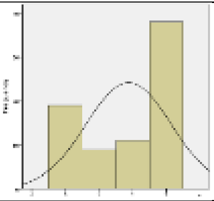
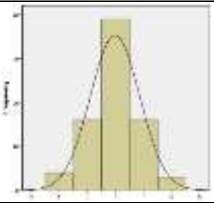
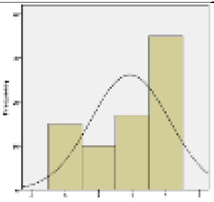
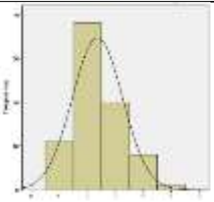
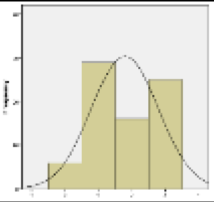
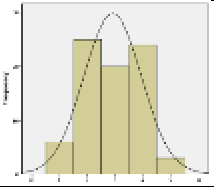
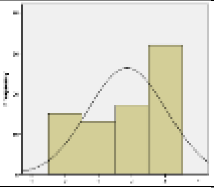
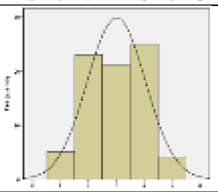
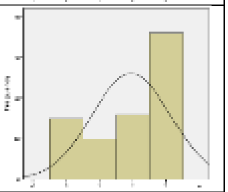
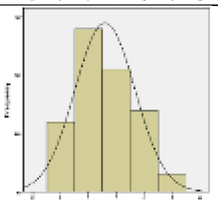
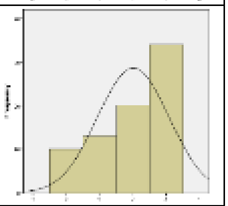
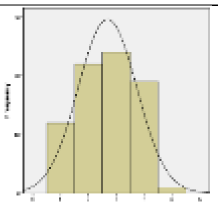
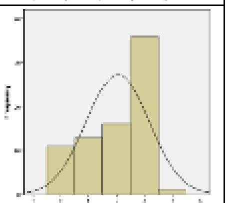
PH27	Increase of defective building elements due to unforeseen weather conditions	2.38	.970		2.06	1.004	
PH28	Extreme exposure of building shell to dust	3.15	.927		1.77	1.297	
PH29	Increase of latent defect problems	2.82	.864		1.92	1.133	
PH30	Damage due to high snow load on buildings	3.15	1.08		1.90	1.199	
PH31	Damage to building assets from frost/snow	2.67	1.02		1.96	1.069	
PH32	Increase of damp, condensation and mould problems in buildings	2.35	.895		1.87	.801	
PH33	Erosion of historic building fabric	2.15	.839		2.06	.894	
PH34	Lightning strike damage to buildings during storms	3.10	1.02		1.62	1.246	
PH35	Slope instability	3.46	1.06		1.64	1.366	

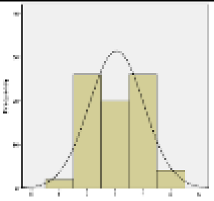
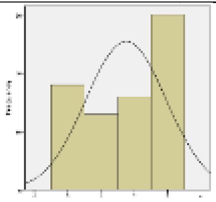
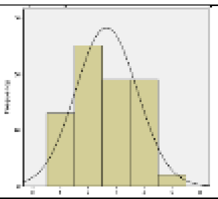
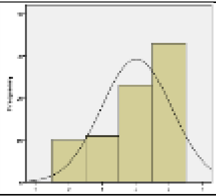
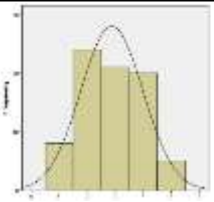
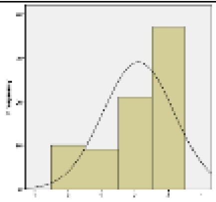
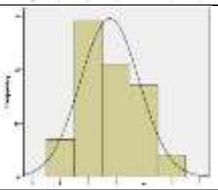
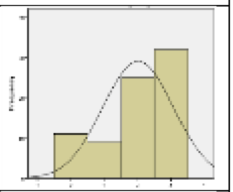
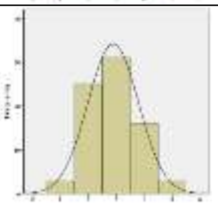
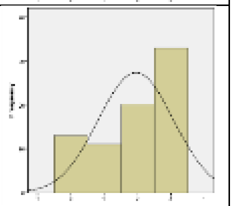
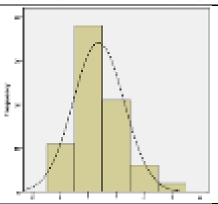
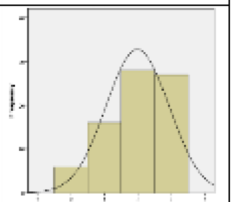
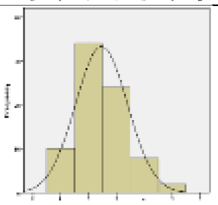
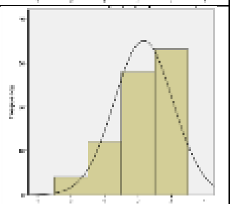
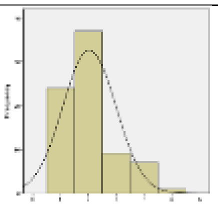
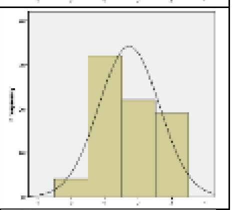
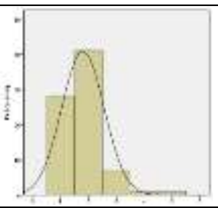
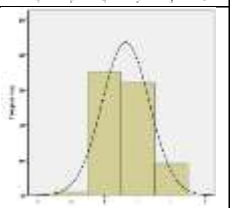
PH36	Insufficient roof drainage in storms	2.38	1.13		1.60	.950	
PH37	Decreased durability and performance of materials	2.41	.918		1.97	1.032	

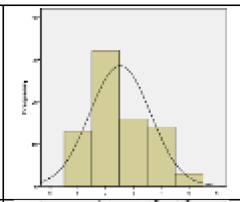
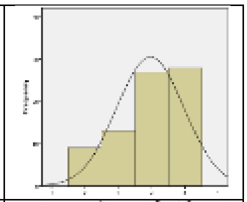
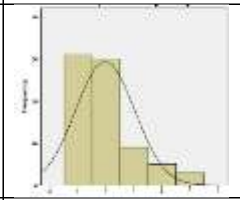
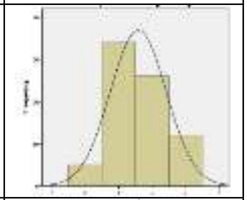
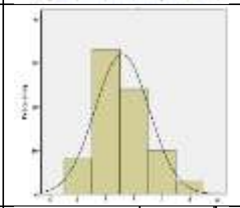
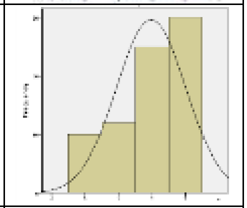
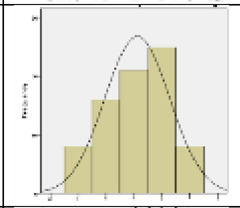
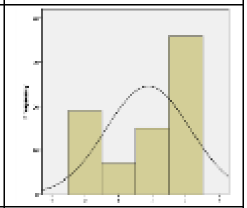
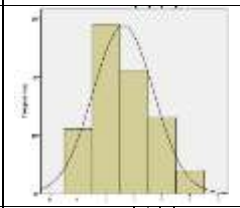
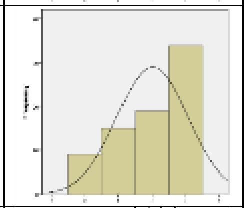
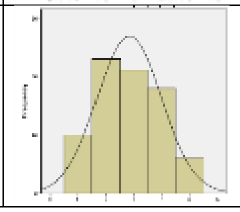
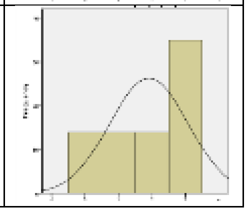
Operational Emerging Risks							
Code	Risk Factors	Likelihood Occurance			Occurance Time scale		
		Mean	S.D	Histogram & Normal Curve	Mean	S.D	Histogram & Normal Curve
OP1	Increase in energy use	1.62	.841		1.27	.641	
OP2	Higher energy prices	1.22	.474		1.13	.409	
OP3	Increasing water costs	1.29	.537		1.26	.497	
OP4	Water use restriction	2.06	1.011		1.57	.818	
OP5	Higher costs of repair	1.67	.715		1.40	.634	
OP6	Increased maintenance regimes	1.77	.788		1.55	.735	
OP7	Electricity brownouts and blackouts	2.17	.813		1.81	.744	
OP8	Increased reliance on mechanical cooling	1.95	.881		1.69	.782	

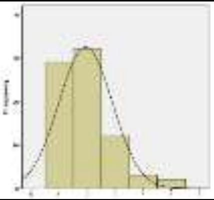
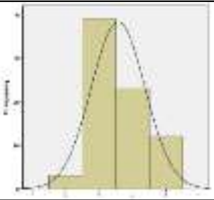
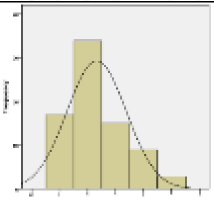
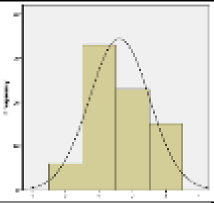
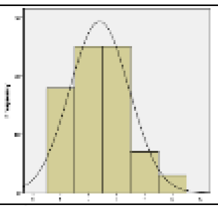
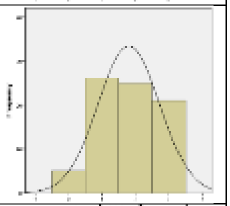
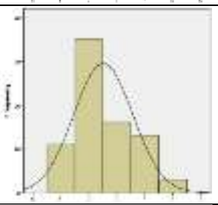
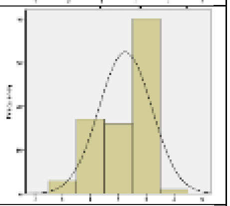
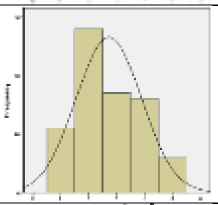
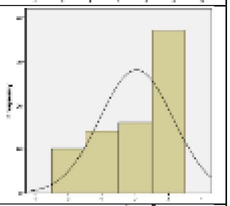
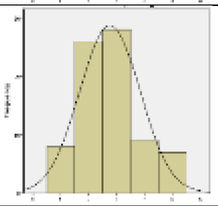
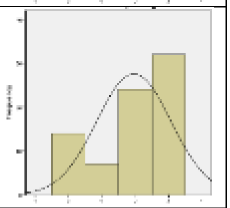
OP9	More frequent mechanical breakdowns	2.36	.868		1.81	.918	
OP10	Reduced access to infrastructure	2.74	.889		1.84	1.136	
OP11	Reduced access to facilities	2.87	.917		1.96	1.106	
OP12	Increased downtime	2.54	.907		2.03	.946	
OP13	Increase in the cost of waste water discharge	1.68	.637		1.51	.737	
OP14	Temporary closure of facilities	2.58	.987		1.88	.923	
OP15	Increased costs due to alternative short-term supplies	2.26	.859		1.92	.796	
OP16	Interruption of supply chain	2.33	.878		1.88	.879	
OP17	Disruptions of telecommunication services	2.45	.907		1.82	.989	

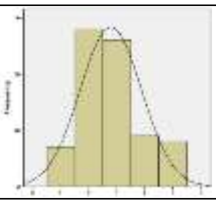
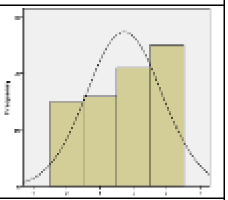
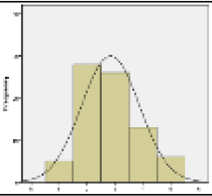
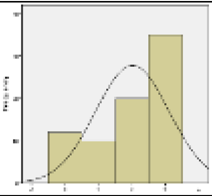
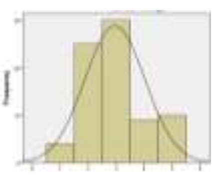
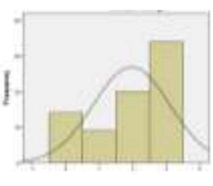
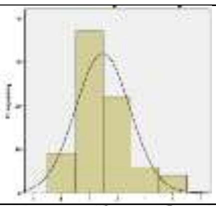
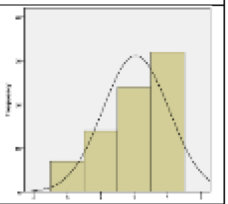
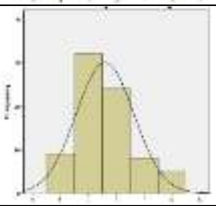
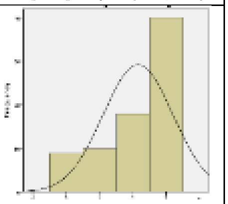
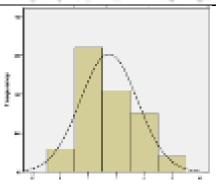
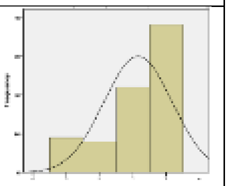
OP18	Increased slips and falls	2.79	.903		1.54	1.160	

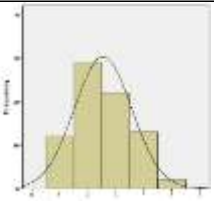
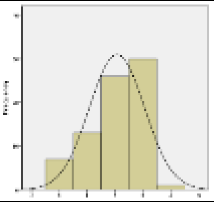
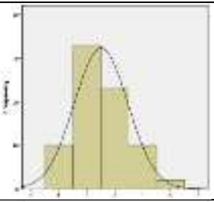
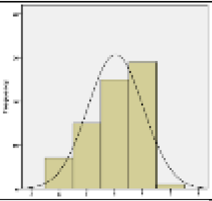
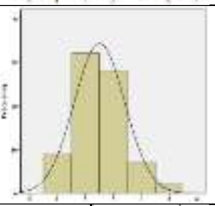
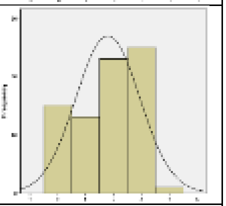
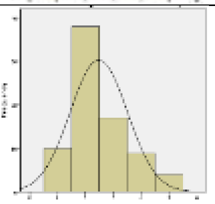
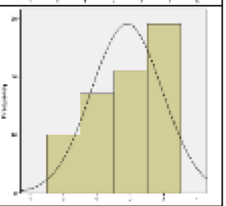
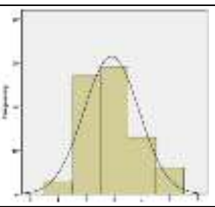
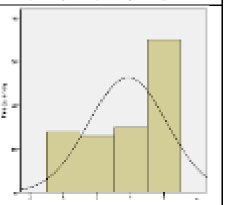
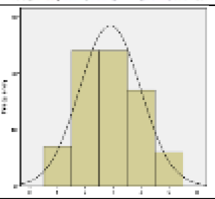
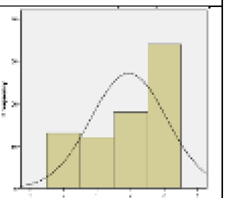
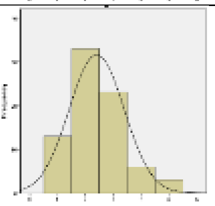
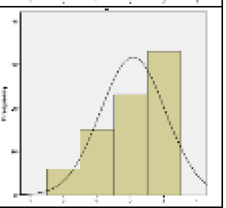
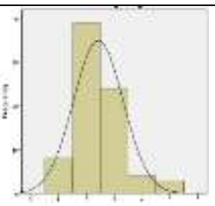
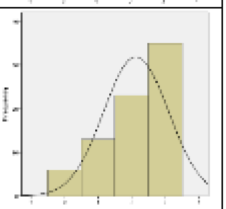
Financial Emerging Risks							
Code	Risk Factors	Likelihood Occurance			Occurance Time scale		
		Mean	S.D	Histogram & Normal Curve	Mean	S.D	Histogram & Normal Curve
F1	Lower profit margins	2.60	.921		1.88	1.000	
F2	Unable to repay debts	3.23	.992		1.88	1.267	
F3	Equity growth not realised	2.97	.882		1.94	1.174	
F4	Increase in administrative expenses	2.36	.897		1.79	.998	
F5	Reduced ability to secure funding for adaptation due to negative property valuation	3.00	1.044		1.86	1.167	
F6	Reduced ability to secure funding for refurbishment due to negative property valuation	2.91	1.047		1.95	1.180	
F7	Fall in value of mal-adapted properties	2.59	1.074		2.01	1.070	
F8	Loss of income from properties	2.68	1.051		2.04	1.129	

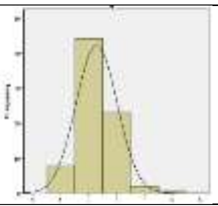
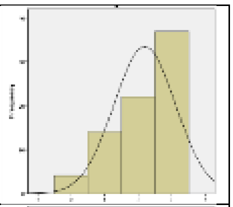
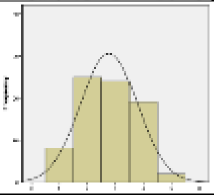
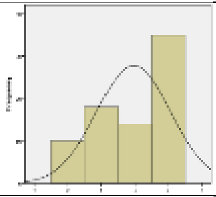
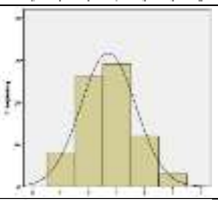
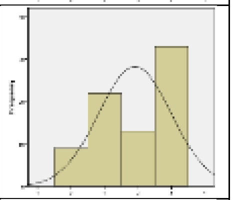
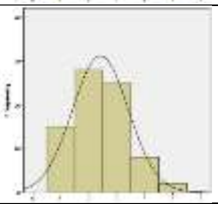
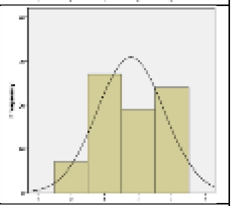
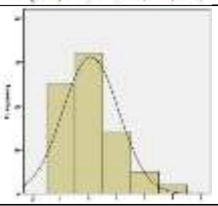
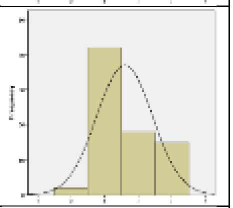
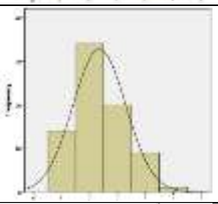
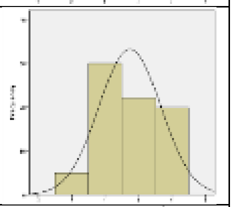
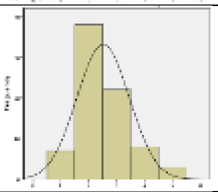
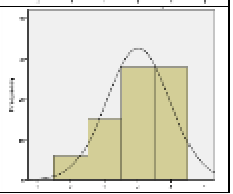
F9	Businesses become less competitive	3.05	.992		1.75	1.205	
F10	Properties may not be saleable because of climate change compliance	2.64	1.105		2.03	1.051	
F11	Negative property valuation due to structural damage	2.87	1.109		2.10	1.059	
F12	Negative property valuation due to services damage or compliance with climate change legislation	2.77	1.056		2.01	1.057	
F13	Loss of revenue due to customer behaviour	2.88	.911		1.95	1.123	
F14	Changing patterns of consumer demand	2.36	.911		1.99	.939	
F15	Affordability of property rent/development	2.46	.935		2.17	.880	
F16	Increase costs to purchase	2.03	.953		1.73	.898	
F17	Increased insurance excess	1.79	.762		1.64	.705	

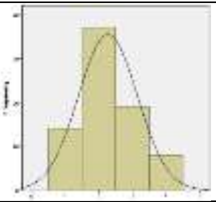
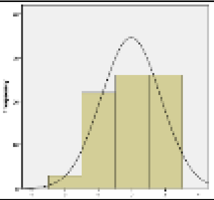
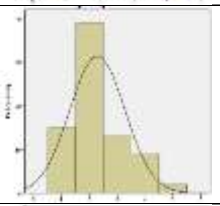
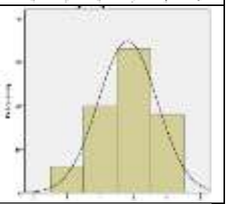
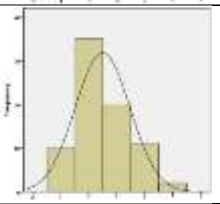
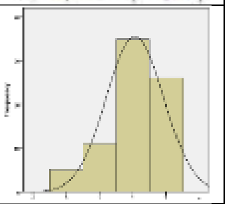
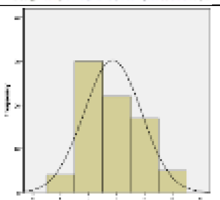
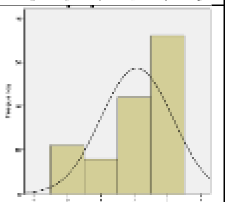
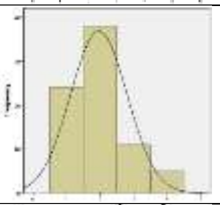
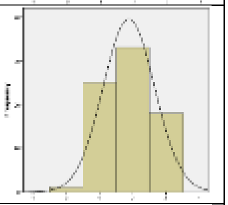
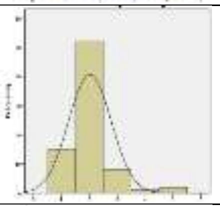
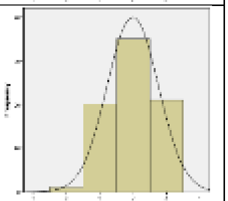
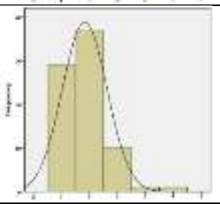
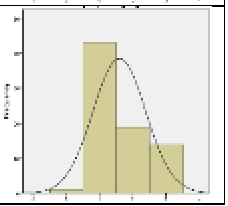
F18	Additional expense in insuring buildings prone to the urban heat island effect	2.51	1.090		1.96	1.006	
F19	Additional expense in insuring buildings in flood risk zones	1.96	1.062		1.58	.833	
F20	Increases in areas prone to soil heave/shrinkage	2.58	.974		1.97	1.038	
F21	Un-insurability due to climate change	3.12	1.162		1.88	1.246	
F22	Affordability of property insurance	2.62	1.084		2.01	1.057	
F23	Availability of property insurance	2.83	1.156		1.91	1.172	

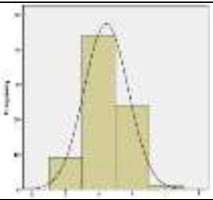
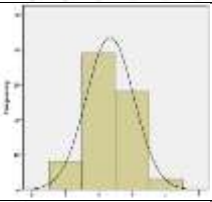
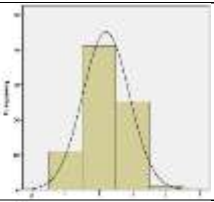
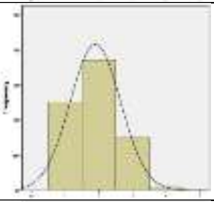
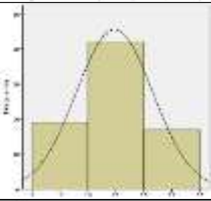
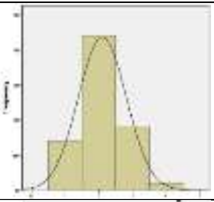
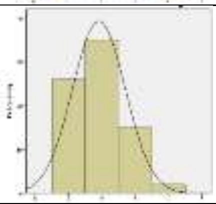
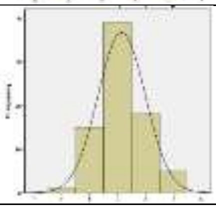
Occupant Dissatisfaction Risks							
Code	Risk Factors	Likelihood Occurance			Occurance Time scale		
		Mean	S.D	Histogram & Normal Curve	Mean	S.D	Histogram & Normal Curve
O1	Thermal discomfort	1.94	.958		1.57	.802	
O2	Loss of productivity	2.32	1.063		1.61	.891	
O3	Heat related health risks	2.38	1.060		1.81	.918	
O4	Usability of Buildings become impaired	2.51	1.054		2.25	.948	
O5	Business continuity impaired	2.72	1.172		2.04	1.094	
O6	Occupant litigation	2.76	1.083		1.96	1.117	

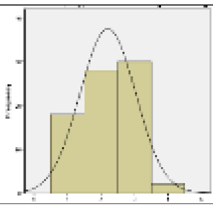
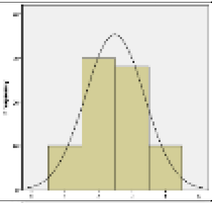
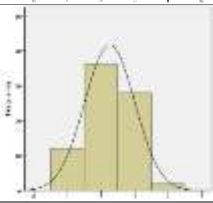
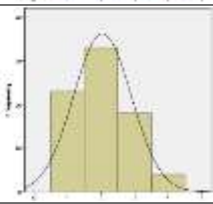
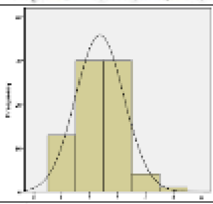
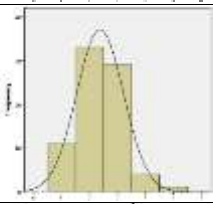
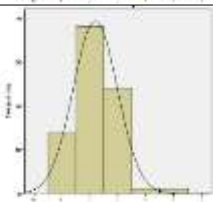
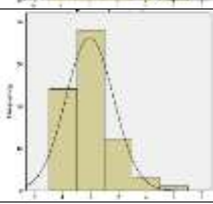
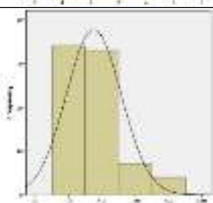
Liability & Responsibility Risks							
Code	Risk Factors	Likelihood Occurance			Occurance Time scale		
		Mean	S.D	Histogram & Normal Curve	Mean	S.D	Histogram & Normal Curve
LR1	Increase of recourse action against professional advisors	2.78	1.101		1.73	1.120	
LR2	Buildings dangerous to health as a result of high temperature	2.83	1.037		2.01	1.106	
LR3	Increase of claims in contract or tort because buildings designed, or operated in a way that has insufficient regard to the reasonably anticipated impacts of climate change	2.95	1.080		1.96	1.141	
LR4	Increasing environmental litigation	2.47	.977		2.05	.985	
LR5	Increasing decommissioning liabilities	2.59	1.037		2.16	1.052	
LR6	Professionals (advisers, designers, owners, tenant, insurers) will bear the responsibility of mal-adapted new buildings	2.73	1.028		2.16	1.027	

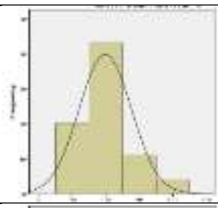
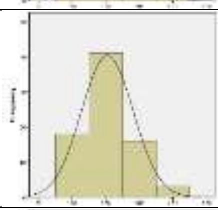
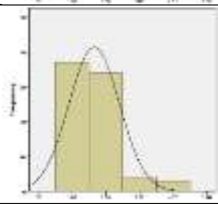
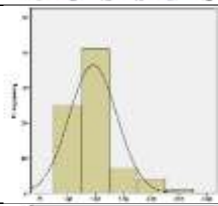
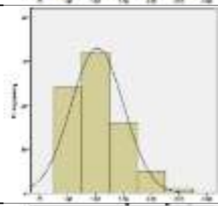
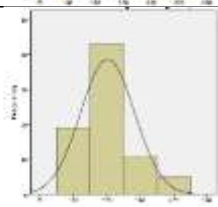
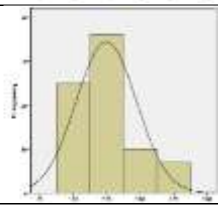
Reputational Emerging Risks							
Code	Risk Factors	Likelihood Occurance			Occurance Time scale		
		Mean	S.D	Histogram & Normal Curve	Mean	S.D	Histogram & Normal Curve
R1	Loss of economic benefits	2.54	1.028		2.06	.991	
R2	Negative impact on corporate social responsibility	2.50	.964		2.03	1.000	
R3	Market differentiation	2.50	.908		1.79	1.139	
R4	Loss of organisations' sustainability credential	2.47	1.028		1.90	1.059	
R5	Loss of investors	2.90	.988		1.92	1.167	
R6	Lower staff retention and productivity due to building usability	2.88	1.093		1.95	1.134	
R7	Higher economic risks	2.40	.985		2.08	.970	
R8	Higher legal risks	2.42	.890		2.13	.965	

R9	Higher liabilities risks	2.28	.737		2.19	.918	
R10	Loss of potential customers due to business interruption	2.77	1.018		1.96	1.106	
R11	Negative impact on organisations' brand and reputation	2.69	.984		1.91	1.090	
R12	Increased sick days	2.41	.999		1.78	.995	
R13	Increased carbon emissions	2.06	.998		1.60	.831	
R14	Increased level of staff stress	2.35	.951		1.74	.923	
R15	Negative impact on organisations reputation from being seen as a contributor to climate change	2.51	.936		2.01	.939	

Regulation Emerging Risks							
Code	Risk Factors	Likelihood Occurance			Occurance Time scale		
		Mean	S.D	Histogram & Normal Curve	Mean	S.D	Histogram & Normal Curve
RE1	Stringent regulation in relation to water stress	2.27	.878		1.97	.888	
RE2	Stringent regulation in relation to flood stress	2.28	.992		1.82	.884	
RE3	Stringent regulation in relation to overheating stress	2.49	.977		2.06	.864	
RE4	Stringent regulation in relation to windstorms stress	2.86	1.028		2.08	1.073	
RE5	Strict limits on greenhouse gas emissions	1.96	.844		1.88	.778	
RE6	mandatory climate change risk-appropriate building regulation	2.01	.764		1.99	.769	
RE7	Uncertainty of pending legislation on climate change	1.82	.802		1.60	.799	

Climate change Risk Management Factors						
Code	Risk Factors	Mean	S.d	Histogram & Normal Curve	Percentage of organisation used	
					Yes	No
RM1	Disruption planning	2.22	.658		42.30%	57.70%
RM2	Balancing resources	2.33	.715		28.20%	71.80%
RM3	Stand-by-preparation	2.21	.691		34.62%	65.38%
RM4	Maintenance planning	1.90	.749		57.70%	42.30%
RM5	Operations planning	1.97	.683		46.15%	53.85%
RM6	Resource planning	2.10	.713		38.46%	61.54%
RM7	Maintenance scheduling	1.91	.793		51.28%	48.72%
RM8	Adaptation planning	2.14	.849		26.92%	73.08%

RM9	Property portfolio climate change risk management	2.21	.827		14.10%	85.90%
RM10	Financial stress emergency plans	2.49	.879		16.66%	83.34%
RM11	Development of new compliance infrastructure	2.26	.746		19.23%	80.77%
RM12	Mitigation plans for disruption to business processes	2.04	.860		35.90%	64.10%
RM13	Plans to deal with changes in market demand	2.36	.868		17.95%	82.05%
RM14	Mitigation plans for disruption to supply chain	2.37	.839		12.82%	87.18%
RM15	Availability of resources	2.19	.790		20.51%	79.49%
RM16	FM strategies to improve properties to reduce emissions	1.96	.860		50.00%	50.00%
RM17	Plans to improve equipment to reduce emissions	1.75	.824		57.70%	42.30%

RM18	Plans to manage water footprint	1.98	.781		47.44%	52.56%
RM19	Plans to use adaptation technology	2.05	.771		32.05%	67.95%
RM20	Strategy to improve energy efficiency	1.65	.752		66.67%	33.33%
RM21	Increasing use of renewable energy	1.91	.855		44.87%	55.13%
RM22	Plans to generate renewable energy on site	2.06	.944		42.30%	57.70%
RM23	Water management mitigation plans	2.06	.805		34.62%	65.38%
RM24	Waste management plans	1.97	.904		61.54%	38.46%

PPENDIX D: ANOVAs rating of likelihood occurrence based on type of organisation

- *Physical Risks*

		Sum of Squares	df	Mean Square	F	Sig.
PH1	Between Groups	6.050	2	3.025	2.814	.066
	Within Groups	80.630	75	1.075		
	Total	86.679	77			
PH2	Between Groups	3.241	2	1.621	1.694	.191
	Within Groups	71.746	75	.957		
	Total	74.987	77			
PH3	Between Groups	.676	2	.338	.403	.670
	Within Groups	62.978	75	.840		
	Total	63.654	77			
PH4	Between Groups	.311	2	.155	.160	.853
	Within Groups	72.984	75	.973		
	Total	73.295	77			
PH5	Between Groups	5.615	2	2.807	2.994	.056
	Within Groups	70.334	75	.938		
	Total	75.949	77			
PH6	Between Groups	.731	2	.366	.365	.696
	Within Groups	75.230	75	1.003		
	Total	75.962	77			
PH7	Between Groups	.179	2	.089	.071	.931
	Within Groups	93.975	75	1.253		
	Total	94.154	77			
PH8	Between Groups	.072	2	.036	.035	.966
	Within Groups	76.608	75	1.021		
	Total	76.679	77			
PH9	Between Groups	.792	2	.396	.513	.601
	Within Groups	57.888	75	.772		
	Total	58.679	77			
PH10	Between Groups	.633	2	.317	.415	.662
	Within Groups	57.162	75	.762		
	Total	57.795	77			
PH11	Between Groups	1.179	2	.589	.580	.562
	Within Groups	76.206	75	1.016		
	Total	77.385	77			
PH12	Between Groups	.735	2	.368	.413	.663
	Within Groups	66.803	75	.891		
	Total	67.538	77			
PH13	Between Groups	.875	2	.437	.444	.643
	Within Groups	73.843	75	.985		
	Total	74.718	77			
PH14	Between Groups	.775	2	.387	.387	.681
	Within Groups	75.174	75	1.002		
	Total	75.949	77			
PH15	Between Groups	.135	2	.067	.071	.932
	Within Groups	71.711	75	.956		
	Total	71.846	77			
PH16	Between Groups	1.134	2	.567	.524	.595
	Within Groups	81.238	75	1.083		
	Total	82.372	77			
PH17	Between Groups	3.343	2	1.671	1.555	.218
	Within Groups	80.606	75	1.075		
	Total	83.949	77			
PH18	Between Groups	7.758	2	3.879	2.986	.057
	Within Groups	97.421	75	1.299		

	Total	105.179	77			
PH19	Between Groups	2.766	2	1.383	1.287	.282
	Within Groups	80.619	75	1.075		
	Total	83.385	77			
PH20	Between Groups	1.024	2	.512	.405	.669
	Within Groups	94.924	75	1.266		
	Total	95.949	77			
PH21	Between Groups	3.551	2	1.776	1.282	.284
	Within Groups	103.898	75	1.385		
	Total	107.449	77			
PH22	Between Groups	.252	2	.126	.127	.881
	Within Groups	74.619	75	.995		
	Total	74.872	77			
PH23	Between Groups	.628	2	.314	.330	.720
	Within Groups	71.321	75	.951		
	Total	71.949	77			
PH24	Between Groups	3.032	2	1.516	1.182	.312
	Within Groups	96.148	75	1.282		
	Total	99.179	77			
PH25	Between Groups	2.410	2	1.205	1.082	.344
	Within Groups	83.539	75	1.114		
	Total	85.949	77			
PH26	Between Groups	1.423	2	.711	.707	.496
	Within Groups	75.462	75	1.006		
	Total	76.885	77			
PH27	Between Groups	.619	2	.309	.323	.725
	Within Groups	71.843	75	.958		
	Total	72.462	77			
PH28	Between Groups	.517	2	.259	.296	.745
	Within Groups	65.636	75	.875		
	Total	66.154	77			
PH29	Between Groups	.602	2	.301	.397	.674
	Within Groups	56.885	75	.758		
	Total	57.487	77			
PH30	Between Groups	.027	2	.013	.011	.989
	Within Groups	90.127	75	1.202		
	Total	90.154	77			
PH31	Between Groups	2.013	2	1.006	.952	.391
	Within Groups	79.321	75	1.058		
	Total	81.333	77			
PH32	Between Groups	.862	2	.431	.532	.590
	Within Groups	60.791	75	.811		
	Total	61.654	77			
PH33	Between Groups	3.302	2	1.651	2.435	.094
	Within Groups	50.852	75	.678		
	Total	54.154	77			
PH34	Between Groups	1.568	2	.784	.739	.481
	Within Groups	79.611	75	1.061		
	Total	81.179	77			
PH35	Between Groups	1.033	2	.516	.449	.640
	Within Groups	86.352	75	1.151		
	Total	87.385	77			
PH36	Between Groups	.161	2	.080	.061	.941
	Within Groups	98.301	75	1.311		
	Total	98.462	77			
PH37	Between Groups	3.466	2	1.733	2.116	.128
	Within Groups	61.406	75	.819		
	Total	64.872	77			

Table ANOVA analysis (F-value and significant value) of physical risks based on type of organisation

- *Operational Risks*

		Sum of Squares	df	Mean Square	F	Sig.
OP1	Between Groups	.205	2	.102	.142	.868
	Within Groups	54.257	75	.723		
	Total	54.462	77			
OP2	Between Groups	.228	2	.114	.502	.607
	Within Groups	17.067	75	.228		
	Total	17.295	77			
OP3	Between Groups	.940	2	.470	1.657	.198
	Within Groups	21.278	75	.284		
	Total	22.218	77			
OP4	Between Groups	2.733	2	1.366	1.349	.266
	Within Groups	75.947	75	1.013		
	Total	78.679	77			
OP5	Between Groups	.388	2	.194	.373	.690
	Within Groups	38.946	75	.519		
	Total	39.333	77			
OP6	Between Groups	1.164	2	.582	.935	.397
	Within Groups	46.682	75	.622		
	Total	47.846	77			
OP7	Between Groups	1.363	2	.682	1.033	.361
	Within Groups	49.470	75	.660		
	Total	50.833	77			
OP8	Between Groups	.495	2	.248	.313	.732
	Within Groups	59.300	75	.791		
	Total	59.795	77			
OP9	Between Groups	1.413	2	.706	.937	.396
	Within Groups	56.536	75	.754		
	Total	57.949	77			
OP10	Between Groups	.397	2	.198	.231	.794
	Within Groups	64.321	75	.858		
	Total	64.718	77			
OP11	Between Groups	.591	2	.295	.367	.694
	Within Groups	60.281	75	.804		
	Total	60.872	77			
OP12	Between Groups	.402	2	.201	.239	.788
	Within Groups	62.983	75	.840		
	Total	63.385	77			
OP13	Between Groups	2.637	2	1.318	3.454	.037
	Within Groups	28.246	74	.382		
	Total	30.883	76			
OP14	Between Groups	1.520	2	.760	.775	.464
	Within Groups	73.519	75	.980		
	Total	75.038	77			
OP15	Between Groups	.236	2	.118	.156	.856
	Within Groups	56.636	75	.755		
	Total	56.872	77			
OP16	Between Groups	.638	2	.319	.408	.667
	Within Groups	58.695	75	.783		
	Total	59.333	77			
OP17	Between Groups	.547	2	.274	.327	.722
	Within Groups	62.748	75	.837		
	Total	63.295	77			
OP18	Between Groups	1.515	2	.757	.928	.400
	Within Groups	61.203	75	.816		
	Total	62.718	77			

Table ANOVA analysis (F-value and significant value) of Operational risks based on type of organisation

- ***Financial Risks***

		Sum of Squares	df	Mean Square	F	Sig.
F1	Between Groups	.797	2	.398	.463	.631
	Within Groups	63.723	74	.861		
	Total	64.519	76			
F2	Between Groups	.280	2	.140	.139	.871
	Within Groups	75.567	75	1.008		
	Total	75.846	77			
F3	Between Groups	1.022	2	.511	.650	.525
	Within Groups	58.927	75	.786		
	Total	59.949	77			
F4	Between Groups	1.457	2	.728	.903	.410
	Within Groups	60.492	75	.807		
	Total	61.949	77			
F5	Between Groups	1.113	2	.557	.501	.608
	Within Groups	83.259	75	1.110		
	Total	84.372	77			
F6	Between Groups	2.801	2	1.401	1.294	.280
	Within Groups	81.199	75	1.083		
	Total	84.000	77			
F7	Between Groups	3.885	2	1.942	1.714	.187
	Within Groups	84.987	75	1.133		
	Total	88.872	77			
F8	Between Groups	.963	2	.481	.430	.652
	Within Groups	84.024	75	1.120		
	Total	84.987	77			
F9	Between Groups	5.928	2	2.964	3.182	.047
	Within Groups	69.867	75	.932		
	Total	75.795	77			
F10	Between Groups	.312	2	.156	.125	.883
	Within Groups	93.637	75	1.248		
	Total	93.949	77			
F11	Between Groups	.362	2	.181	.144	.866
	Within Groups	94.356	75	1.258		
	Total	94.718	77			
F12	Between Groups	.680	2	.340	.299	.742
	Within Groups	85.166	75	1.136		
	Total	85.846	77			
F13	Between Groups	.060	2	.030	.035	.965
	Within Groups	63.901	75	.852		
	Total	63.962	77			
F14	Between Groups	.415	2	.207	.245	.784
	Within Groups	63.534	75	.847		
	Total	63.949	77			
F15	Between Groups	.402	2	.201	.225	.799
	Within Groups	66.983	75	.893		
	Total	67.385	77			
F16	Between Groups	3.460	2	1.730	1.952	.149
	Within Groups	66.488	75	.887		
	Total	69.949	77			
F17	Between Groups	.479	2	.240	.406	.668
	Within Groups	44.239	75	.590		
	Total	44.718	77			
F18	Between Groups	1.230	2	.615	.511	.602
	Within Groups	90.257	75	1.203		
	Total	91.487	77			
F19	Between Groups	12.655	2	6.327	6.393	.003
	Within Groups	74.230	75	.990		
	Total	86.885	77			
F20	Between Groups	2.894	2	1.447	1.547	.220
	Within Groups	70.144	75	.935		

	Total	73.038	77			
F21	Between Groups	2.002	2	1.001	.736	.482
	Within Groups	101.960	75	1.359		
	Total	103.962	77			
F22	Between Groups	.425	2	.212	.177	.838
	Within Groups	90.037	75	1.200		
	Total	90.462	77			
F23	Between Groups	.762	2	.381	.280	.757
	Within Groups	102.071	75	1.361		
	Total	102.833	77			

Table ANOVA analysis (F-value and significant value) of Financial risks based on type of organisation

- *Occupant dissatisfaction risks*

		Sum of Squares	df	Mean Square	F	Sig.
O1	Between Groups	1.273	2	.636	.688	.506
	Within Groups	69.407	75	.925		
	Total	70.679	77			
O2	Between Groups	1.350	2	.675	.591	.556
	Within Groups	85.638	75	1.142		
	Total	86.987	77			
O3	Between Groups	1.188	2	.594	.522	.595
	Within Groups	85.274	75	1.137		
	Total	86.462	77			
O4	Between Groups	1.276	2	.638	.568	.569
	Within Groups	84.211	75	1.123		
	Total	85.487	77			
O5	Between Groups	.605	2	.302	.216	.807
	Within Groups	105.190	75	1.403		
	Total	105.795	77			
O6	Between Groups	.345	2	.173	.144	.866
	Within Groups	90.027	75	1.200		
	Total	90.372	77			

Table ANOVA analysis (F-value and significant value) of Occupant dissatisfaction risks based on type of organisation

- ***Liability and Responsibility Risks***

		Sum of Squares	df	Mean Square	F	Sig.
LR1	Between Groups	.888	2	.444	.360	.699
	Within Groups	92.407	75	1.232		
	Total	93.295	77			
LR12	Between Groups	1.061	2	.531	.487	.617
	Within Groups	81.772	75	1.090		
	Total	82.833	77			
LR3	Between Groups	1.734	2	.867	.739	.481
	Within Groups	88.061	75	1.174		
	Total	89.795	77			
LR4	Between Groups	2.974	2	1.487	1.582	.212
	Within Groups	70.475	75	.940		
	Total	73.449	77			
LR5	Between Groups	1.917	2	.958	.888	.416
	Within Groups	80.955	75	1.079		
	Total	82.872	77			
LR6	Between Groups	1.622	2	.811	.763	.470
	Within Groups	79.724	75	1.063		
	Total	81.346	77			

Table ANOVA analysis (F-value and significant value) of Liability & Responsibility risks based on type of organisation

- ***Reputational Risks***

		Sum of Squares	df	Mean Square	F	Sig.
R1	Between Groups	1.151	2	.575	.538	.586
	Within Groups	80.234	75	1.070		
	Total	81.385	77			
R2	Between Groups	3.485	2	1.742	1.921	.154
	Within Groups	68.015	75	.907		
	Total	71.500	77			
R3	Between Groups	.570	2	.285	.340	.713
	Within Groups	62.930	75	.839		
	Total	63.500	77			
R4	Between Groups	.541	2	.270	.251	.779
	Within Groups	80.908	75	1.079		
	Total	81.449	77			
R5	Between Groups	1.061	2	.530	.537	.587
	Within Groups	74.119	75	.988		
	Total	75.179	77			
R6	Between Groups	.714	2	.357	.293	.747
	Within Groups	91.248	75	1.217		
	Total	91.962	77			
R7	Between Groups	2.425	2	1.213	1.259	.290
	Within Groups	72.254	75	.963		
	Total	74.679	77			
R8	Between Groups	.611	2	.305	.379	.686
	Within Groups	60.428	75	.806		
	Total	61.038	77			
R9	Between Groups	.375	2	.188	.340	.713
	Within Groups	41.419	75	.552		
	Total	41.795	77			
R10	Between Groups	2.326	2	1.163	1.125	.330
	Within Groups	77.520	75	1.034		

	Total	79.846	77			
R11	Between Groups	4.316	2	2.158	2.302	.107
	Within Groups	70.299	75	.937		
	Total	74.615	77			
R12	Between Groups	2.238	2	1.119	1.124	.330
	Within Groups	74.634	75	.995		
	Total	76.872	77			
R13	Between Groups	1.817	2	.909	.910	.407
	Within Groups	74.862	75	.998		
	Total	76.679	77			
R14	Between Groups	6.699	2	3.349	3.990	**.023**
	Within Groups	62.955	75	.839		
	Total	69.654	77			
R15	Between Groups	.162	2	.081	.090	.914
	Within Groups	67.325	75	.898		
	Total	67.487	77			

Table ANOVA analysis (F-value and significant value) of Reputational risks based on type of organisation

- *Regulatory Risks*

		Sum of Squares	df	Mean Square	F	Sig.
RE1	Between Groups	.475	2	.237	.302	.740
	Within Groups	58.871	75	.785		
	Total	59.346	77			
RE2	Between Groups	1.033	2	.516	.518	.598
	Within Groups	74.762	75	.997		
	Total	75.795	77			
RE3	Between Groups	1.953	2	.977	1.024	.364
	Within Groups	71.534	75	.954		
	Total	73.487	77			
RE4	Between Groups	.508	2	.254	.235	.791
	Within Groups	80.941	75	1.079		
	Total	81.449	77			
RE5	Between Groups	.782	2	.391	.542	.584
	Within Groups	54.103	75	.721		
	Total	54.885	77			
RE6	Between Groups	1.086	2	.543	.928	.400
	Within Groups	43.901	75	.585		
	Total	44.987	77			
RE7	Between Groups	.072	2	.036	.055	.947
	Within Groups	49.415	75	.659		
	Total	49.487	77			

Table ANOVA analysis (F-value and significant value) of Regulation risks based on type of organisation

ANOVAs Rating of Likelihood Occurrence Based on Professional Roles

- ***Physical Risks***

		Sum of Squares	df	Mean Square	F	Sig.
PH1	Between Groups	.304	2	.152	.132	.877
	Within Groups	85.488	74	1.155		
	Total	85.792	76			
PH2	Between Groups	1.119	2	.560	.564	.571
	Within Groups	73.400	74	.992		
	Total	74.519	76			
PH3	Between Groups	.594	2	.297	.359	.700
	Within Groups	61.224	74	.827		
	Total	61.818	76			
PH4	Between Groups	1.184	2	.592	.613	.544
	Within Groups	71.491	74	.966		
	Total	72.675	76			
PH5	Between Groups	2.584	2	1.292	1.322	.273
	Within Groups	72.299	74	.977		
	Total	74.883	76			
PH6	Between Groups	.668	2	.334	.334	.717
	Within Groups	74.033	74	1.000		
	Total	74.701	76			
PH7	Between Groups	4.287	2	2.144	1.792	.174
	Within Groups	88.518	74	1.196		
	Total	92.805	76			
PH8	Between Groups	8.147	2	4.073	4.529	.014
	Within Groups	66.555	74	.899		
	Total	74.701	76			
PH9	Between Groups	1.493	2	.746	.981	.380
	Within Groups	56.299	74	.761		
	Total	57.792	76			
PH10	Between Groups	.167	2	.083	.115	.891
	Within Groups	53.366	74	.721		
	Total	53.532	76			
PH11	Between Groups	1.635	2	.818	.825	.442
	Within Groups	73.352	74	.991		
	Total	74.987	76			
PH12	Between Groups	8.024	2	4.012	5.062	.009
	Within Groups	58.652	74	.793		
	Total	66.675	76			
PH13	Between Groups	11.073	2	5.537	6.516	.002
	Within Groups	62.875	74	.850		
	Total	73.948	76			
PH14	Between Groups	12.699	2	6.350	7.543	.001
	Within Groups	62.288	74	.842		
	Total	74.987	76			
PH15	Between Groups	7.821	2	3.910	4.631	.013
	Within Groups	62.491	74	.844		
	Total	70.312	76			
PH16	Between Groups	4.897	2	2.448	2.387	.099
	Within Groups	75.908	74	1.026		
	Total	80.805	76			
PH17	Between Groups	3.290	2	1.645	1.527	.224
	Within Groups	79.697	74	1.077		
	Total	82.987	76			
PH18	Between Groups	2.225	2	1.112	.816	.446
	Within Groups	100.866	74	1.363		
	Total	103.091	76			
PH19	Between Groups	.530	2	.265	.243	.785
	Within Groups	80.691	74	1.090		

	Total	81.221	76			
PH20	Between Groups Within Groups Total	1.458 91.763 93.221	2 74 76	.729 1.240	.588	.558
PH21	Between Groups Within Groups Total	4.703 102.518 107.221	2 74 76	2.351 1.385	1.697	.190
PH22	Between Groups Within Groups Total	.232 74.288 74.519	2 74 76	.116 1.004	.115	.891
PH23	Between Groups Within Groups Total	5.201 62.591 67.792	2 74 76	2.601 .846	3.075	.052
PH24	Between Groups Within Groups Total	.069 98.788 98.857	2 74 76	.035 1.335	.026	.974
PH25	Between Groups Within Groups Total	2.978 82.555 85.532	2 74 76	1.489 1.116	1.335	.270
PH26	Between Groups Within Groups Total	.108 76.775 76.883	2 74 76	.054 1.037	.052	.949
PH27	Between Groups Within Groups Total	.125 69.693 69.818	2 74 76	.062 .942	.066	.936
PH28	Between Groups Within Groups Total	.933 65.197 66.130	2 74 76	.466 .881	.529	.591
PH29	Between Groups Within Groups Total	1.342 51.333 52.675	2 74 76	.671 .694	.967	.385
PH30	Between Groups Within Groups Total	4.666 84.763 89.429	2 74 76	2.333 1.145	2.037	.138
PH31	Between Groups Within Groups Total	.469 79.064 79.532	2 74 76	.234 1.068	.219	.804
PH32	Between Groups Within Groups Total	.015 61.206 61.221	2 74 76	.007 .827	.009	.991
PH33	Between Groups Within Groups Total	1.504 49.197 50.701	2 74 76	.752 .665	1.131	.328
PH34	Between Groups Within Groups Total	2.692 77.672 80.364	2 74 76	1.346 1.050	1.282	.284
PH35	Between Groups Within Groups Total	1.067 86.024 87.091	2 74 76	.533 1.162	.459	.634
PH36	Between Groups Within Groups Total	1.279 96.799 98.078	2 74 76	.639 1.308	.489	.615
PH37	Between Groups Within Groups Total	1.082 61.230 62.312	2 74 76	.541 .827	.654	.523

Table ANOVA analysis (F-value and significant value) of Physical risks based on role in organisation

- *Operational Risks*

		Sum of Squares	df	Mean Square	F	Sig.
OP1	Between Groups	.150	2	.075	.114	.892
	Within Groups	48.552	74	.656		
	Total	48.701	76			
OP2	Between Groups	.703	2	.351	1.628	.203
	Within Groups	15.973	74	.216		
	Total	16.675	76			
OP3	Between Groups	.617	2	.309	1.083	.344
	Within Groups	21.097	74	.285		
	Total	21.714	76			
OP4	Between Groups	2.569	2	1.285	1.249	.293
	Within Groups	76.106	74	1.028		
	Total	78.675	76			
OP5	Between Groups	.552	2	.276	.614	.544
	Within Groups	33.266	74	.450		
	Total	33.818	76			
OP6	Between Groups	1.224	2	.612	1.089	.342
	Within Groups	41.581	74	.562		
	Total	42.805	76			
OP7	Between Groups	.729	2	.365	.578	.564
	Within Groups	46.699	74	.631		
	Total	47.429	76			
OP8	Between Groups	2.469	2	1.235	1.625	.204
	Within Groups	56.206	74	.760		
	Total	58.675	76			
OP9	Between Groups	1.357	2	.679	.932	.398
	Within Groups	53.864	74	.728		
	Total	55.221	76			
OP10	Between Groups	3.504	2	1.752	2.164	.122
	Within Groups	59.924	74	.810		
	Total	63.429	76			
OP11	Between Groups	1.534	2	.767	.983	.379
	Within Groups	57.739	74	.780		
	Total	59.273	76			
OP12	Between Groups	1.369	2	.685	.846	.433
	Within Groups	59.852	74	.809		
	Total	61.221	76			
OP13	Between Groups	.324	2	.162	.388	.680
	Within Groups	30.452	73	.417		
	Total	30.776	75			
OP14	Between Groups	.296	2	.148	.151	.860
	Within Groups	72.691	74	.982		
	Total	72.987	76			
OP15	Between Groups	3.672	2	1.836	2.557	.084
	Within Groups	53.133	74	.718		
	Total	56.805	76			
OP16	Between Groups	2.595	2	1.298	1.706	.189
	Within Groups	56.288	74	.761		
	Total	58.883	76			
OP17	Between Groups	1.157	2	.579	.693	.503
	Within Groups	61.830	74	.836		
	Total	62.987	76			
OP18	Between Groups	1.941	2	.970	1.211	.304
	Within Groups	59.306	74	.801		
	Total	61.247	76			

Table ANOVA analysis (F-value and significant value) of Operational risks based on role in organisation

- *Financial Risks*

		Sum of Squares	df	Mean Square	F	Sig.
F1	Between Groups	.641	2	.320	.378	.687
	Within Groups	61.886	73	.848		
	Total	62.526	75			
F2	Between Groups	1.395	2	.698	.699	.500
	Within Groups	73.852	74	.998		
	Total	75.247	76			
F3	Between Groups	.775	2	.387	.493	.613
	Within Groups	58.108	74	.785		
	Total	58.883	76			
F4	Between Groups	.845	2	.422	.515	.600
	Within Groups	60.688	74	.820		
	Total	61.532	76			
F5	Between Groups	2.521	2	1.261	1.157	.320
	Within Groups	80.648	74	1.090		
	Total	83.169	76			
F6	Between Groups	1.860	2	.930	.849	.432
	Within Groups	81.127	74	1.096		
	Total	82.987	76			
F7	Between Groups	1.823	2	.911	.778	.463
	Within Groups	86.697	74	1.172		
	Total	88.519	76			
F8	Between Groups	1.949	2	.974	.887	.416
	Within Groups	81.272	74	1.098		
	Total	83.221	76			
F9	Between Groups	.132	2	.066	.065	.937
	Within Groups	74.752	74	1.010		
	Total	74.883	76			
F10	Between Groups	.054	2	.027	.022	.979
	Within Groups	92.024	74	1.244		
	Total	92.078	76			
F11	Between Groups	4.390	2	2.195	1.824	.169
	Within Groups	89.039	74	1.203		
	Total	93.429	76			
F12	Between Groups	2.121	2	1.060	.955	.390
	Within Groups	82.191	74	1.111		
	Total	84.312	76			
F13	Between Groups	4.630	2	2.315	2.888	.062
	Within Groups	59.318	74	.802		
	Total	63.948	76			
F14	Between Groups	4.864	2	2.432	3.052	.053
	Within Groups	58.955	74	.797		
	Total	63.818	76			
F15	Between Groups	4.728	2	2.364	2.805	.067
	Within Groups	62.363	74	.843		
	Total	67.091	76			
F16	Between Groups	2.619	2	1.309	1.439	.244
	Within Groups	67.330	74	.910		
	Total	69.948	76			
F17	Between Groups	.751	2	.376	.633	.534
	Within Groups	43.924	74	.594		
	Total	44.675	76			
F18	Between Groups	.859	2	.429	.360	.699
	Within Groups	88.388	74	1.194		
	Total	89.247	76			
F19	Between Groups	.460	2	.230	.199	.820
	Within Groups	85.488	74	1.155		
	Total	85.948	76			
F20	Between Groups	1.513	2	.757	.787	.459

	Within Groups	71.188	74	.962		
	Total	72.701	76			
F21	Between Groups	2.917	2	1.459	1.077	.346
	Within Groups	100.252	74	1.355		
	Total	103.169	76			
F22	Between Groups	2.460	2	1.230	1.036	.360
	Within Groups	87.852	74	1.187		
	Total	90.312	76			
F23	Between Groups	1.451	2	.725	.530	.591
	Within Groups	101.355	74	1.370		
	Total	102.805	76			

Table ANOVA analysis (F-value and significant value) of Financial risks based on role in organisation

- ***Occupant dissatisfaction Risks***

		Sum of Squares	df	Mean Square	F	Sig.
O1	Between Groups	1.539	2	.770	.838	.437
	Within Groups	67.993	74	.919		
	Total	69.532	76			
O2	Between Groups	3.342	2	1.671	1.531	.223
	Within Groups	80.788	74	1.092		
	Total	84.130	76			
O3	Between Groups	3.800	2	1.900	1.757	.180
	Within Groups	80.018	74	1.081		
	Total	83.818	76			
O4	Between Groups	2.684	2	1.342	1.233	.297
	Within Groups	80.563	74	1.089		
	Total	83.247	76			
O5	Between Groups	3.358	2	1.679	1.233	.297
	Within Groups	100.772	74	1.362		
	Total	104.130	76			
O6	Between Groups	.908	2	.454	.382	.684
	Within Groups	87.897	74	1.188		
	Total	88.805	76			

Table ANOVA analysis (F-value and significant value) of Occupant dissatisfaction risks based on role in organisation

- *Liability and Responsibility Risks*

		Sum of Squares	df	Mean Square	F	Sig.
LR1	Between Groups	3.526	2	1.763	1.478	.235
	Within Groups	88.266	74	1.193		
	Total	91.792	76			
LR12	Between Groups	3.480	2	1.740	1.651	.199
	Within Groups	77.975	74	1.054		
	Total	81.455	76			
LR3	Between Groups	7.149	2	3.574	3.244	.045
	Within Groups	81.527	74	1.102		
	Total	88.675	76			
LR4	Between Groups	4.142	2	2.071	2.220	.116
	Within Groups	69.027	74	.933		
	Total	73.169	76			
LR5	Between Groups	8.813	2	4.407	4.424	.015
	Within Groups	73.706	74	.996		
	Total	82.519	76			
LR6	Between Groups	2.192	2	1.096	1.025	.364
	Within Groups	79.081	74	1.069		
	Total	81.273	76			

Table ANOVA analysis (F-value and significant value) of Liability & Responsibility risks based on role in organisation

- *Reputational risks*

		Sum of Squares	df	Mean Square	F	Sig.
R1	Between Groups	2.387	2	1.194	1.150	.322
	Within Groups	76.833	74	1.038		
	Total	79.221	76			
R2	Between Groups	2.148	2	1.074	1.185	.311
	Within Groups	67.073	74	.906		
	Total	69.221	76			
R3	Between Groups	.159	2	.079	.093	.911
	Within Groups	63.088	74	.853		
	Total	63.247	76			
R4	Between Groups	10.005	2	5.003	5.202	.008
	Within Groups	71.164	74	.962		
	Total	81.169	76			
R5	Between Groups	5.100	2	2.550	2.741	.071
	Within Groups	68.848	74	.930		
	Total	73.948	76			
R6	Between Groups	3.819	2	1.909	1.603	.208
	Within Groups	88.130	74	1.191		
	Total	91.948	76			
R7	Between Groups	2.851	2	1.426	1.524	.225
	Within Groups	69.227	74	.935		
	Total	72.078	76			
R8	Between Groups	3.054	2	1.527	2.037	.138
	Within Groups	55.466	74	.750		
	Total	58.519	76			
R9	Between Groups	1.506	2	.753	1.494	.231
	Within Groups	37.299	74	.504		

	Total	38.805	76			
R10	Between Groups	1.385	2	.693	.666	.517
	Within Groups	76.927	74	1.040		
	Total	78.312	76			
R11	Between Groups	2.668	2	1.334	1.374	.260
	Within Groups	71.852	74	.971		
	Total	74.519	76			
R12	Between Groups	1.149	2	.574	.581	.562
	Within Groups	73.163	74	.989		
	Total	74.312	76			
R13	Between Groups	5.944	2	2.972	3.286	.043
	Within Groups	66.939	74	.905		
	Total	72.883	76			
R14	Between Groups	1.084	2	.542	.609	.546
	Within Groups	65.799	74	.889		
	Total	66.883	76			
R15	Between Groups	1.082	2	.541	.599	.552
	Within Groups	65.905	73	.903		
	Total	66.987	75			

Table ANOVA analysis (F-value and significant value) of Reputational risks based on role in organisation

- *Regulatory Risks*

		Sum of Squares	df	Mean Square	F	Sig.
RE1	Between Groups	2.151	2	1.075	1.405	.252
	Within Groups	56.655	74	.766		
	Total	58.805	76			
RE2	Between Groups	2.551	2	1.276	1.290	.281
	Within Groups	73.163	74	.989		
	Total	75.714	76			
RE3	Between Groups	7.688	2	3.844	4.481	**.015**
	Within Groups	63.481	74	.858		
	Total	71.169	76			
RE4	Between Groups	8.558	2	4.279	4.424	**.015**
	Within Groups	71.572	74	.967		
	Total	80.130	76			
RE5	Between Groups	.775	2	.387	.530	.591
	Within Groups	54.108	74	.731		
	Total	54.883	76			
RE6	Between Groups	5.139	2	2.570	4.772	**.011**
	Within Groups	39.848	74	.538		
	Total	44.987	76			
RE7	Between Groups	3.967	2	1.983	3.227	**.045**
	Within Groups	45.488	74	.615		
	Total	49.455	76			

Table ANOVA analysis (F-value and significant value) of Regulation risks based on role in organisation

ANOVAs Rating Occurrence Time-Frame Based on type of organisation

- *Physical Risks*

		Sum of Squares	df	Mean Square	F	Sig.
PH1	Between Groups	.578	2	.289	.212	.809
	Within Groups	100.876	74	1.363		
	Total	101.455	76			
PH2	Between Groups	.598	2	.299	.149	.862
	Within Groups	148.285	74	2.004		
	Total	148.883	76			
PH3	Between Groups	.819	2	.409	.335	.716
	Within Groups	90.428	74	1.222		
	Total	91.247	76			
PH4	Between Groups	3.908	2	1.954	1.087	.342
	Within Groups	132.975	74	1.797		
	Total	136.883	76			
PH5	Between Groups	1.303	2	.652	.461	.633
	Within Groups	104.645	74	1.414		
	Total	105.948	76			
PH6	Between Groups	4.527	2	2.263	1.837	.167
	Within Groups	91.187	74	1.232		
	Total	95.714	76			
PH7	Between Groups	2.255	2	1.127	.815	.447
	Within Groups	102.421	74	1.384		
	Total	104.675	76			
PH8	Between Groups	.351	2	.175	.223	.800
	Within Groups	58.169	74	.786		
	Total	58.519	76			
PH9	Between Groups	2.459	2	1.230	1.732	.184
	Within Groups	52.528	74	.710		
	Total	54.987	76			
PH10	Between Groups	3.329	2	1.665	2.335	.104
	Within Groups	52.749	74	.713		
	Total	56.078	76			
PH11	Between Groups	.682	2	.341	.382	.684
	Within Groups	66.019	74	.892		
	Total	66.701	76			
PH12	Between Groups	3.137	2	1.568	.924	.401
	Within Groups	125.565	74	1.697		
	Total	128.701	76			
PH13	Between Groups	5.888	2	2.944	1.609	.207
	Within Groups	135.359	74	1.829		
	Total	141.247	76			
PH14	Between Groups	5.204	2	2.602	1.620	.205
	Within Groups	118.874	74	1.606		
	Total	124.078	76			
PH15	Between Groups	1.109	2	.554	.422	.657
	Within Groups	97.255	74	1.314		
	Total	98.364	76			
PH16	Between Groups	1.023	2	.512	.411	.665
	Within Groups	92.145	74	1.245		
	Total	93.169	76			
PH17	Between Groups	.143	2	.072	.102	.904
	Within Groups	52.169	74	.705		
	Total	52.312	76			
PH18	Between Groups	1.690	2	.845	.847	.433
	Within Groups	73.842	74	.998		
	Total	75.532	76			
PH19	Between Groups	1.327	2	.664	.657	.521

	Within Groups	74.751	74	1.010		
	Total	76.078	76			
PH20	Between Groups	1.416	2	.708	.724	.488
	Within Groups	72.376	74	.978		
	Total	73.792	76			
PH21	Between Groups	2.837	2	1.419	1.252	.292
	Within Groups	83.838	74	1.133		
	Total	86.675	76			
PH22	Between Groups	2.292	2	1.146	1.311	.276
	Within Groups	64.695	74	.874		
	Total	66.987	76			
PH23	Between Groups	.357	2	.179	.220	.803
	Within Groups	60.162	74	.813		
	Total	60.519	76			
PH24	Between Groups	3.171	2	1.586	.839	.436
	Within Groups	139.920	74	1.891		
	Total	143.091	76			
PH25	Between Groups	1.927	2	.964	.477	.623
	Within Groups	149.605	74	2.022		
	Total	151.532	76			
PH26	Between Groups	2.114	2	1.057	.790	.458
	Within Groups	99.054	74	1.339		
	Total	101.169	76			
PH27	Between Groups	1.966	2	.983	.973	.383
	Within Groups	74.710	74	1.010		
	Total	76.675	76			
PH28	Between Groups	5.144	2	2.572	1.552	.219
	Within Groups	122.649	74	1.657		
	Total	127.792	76			
PH29	Between Groups	1.094	2	.547	.420	.659
	Within Groups	96.439	74	1.303		
	Total	97.532	76			
PH30	Between Groups	.555	2	.278	.189	.828
	Within Groups	108.614	74	1.468		
	Total	109.169	76			
PH31	Between Groups	.387	2	.194	.166	.848
	Within Groups	86.496	74	1.169		
	Total	86.883	76			
PH32	Between Groups	4.708	2	2.354	3.960	.023
	Within Groups	43.993	74	.595		
	Total	48.701	76			
PH33	Between Groups	1.813	2	.907	1.140	.325
	Within Groups	58.862	74	.795		
	Total	60.675	76			
PH34	Between Groups	.273	2	.137	.086	.918
	Within Groups	117.805	74	1.592		
	Total	118.078	76			
PH35	Between Groups	.578	2	.289	.151	.860
	Within Groups	141.241	74	1.909		
	Total	141.818	76			
PH36	Between Groups	3.274	2	1.637	1.857	.163
	Within Groups	65.245	74	.882		
	Total	68.519	76			
PH37	Between Groups	.391	2	.195	.179	.836
	Within Groups	79.557	73	1.090		
	Total	79.947	75			

Table ANOVA analysis (F-value and significant value) of physical risks based on type of organisation

- *Operational Risks*

		Sum of Squares	df	Mean Square	F	Sig.
OP1	Between Groups	1.598	2	.799	1.992	.144
	Within Groups	29.675	74	.401		
	Total	31.273	76			
OP2	Between Groups	.105	2	.052	.307	.737
	Within Groups	12.597	74	.170		
	Total	12.701	76			
OP3	Between Groups	.795	2	.398	1.634	.202
	Within Groups	18.010	74	.243		
	Total	18.805	76			
OP4	Between Groups	.318	2	.159	.233	.793
	Within Groups	50.540	74	.683		
	Total	50.857	76			
OP5	Between Groups	.754	2	.377	.938	.396
	Within Groups	29.765	74	.402		
	Total	30.519	76			
OP6	Between Groups	5.790	2	2.895	6.068	**.004**
	Within Groups	35.301	74	.477		
	Total	41.091	76			
OP7	Between Groups	1.160	2	.580	1.049	.355
	Within Groups	40.918	74	.553		
	Total	42.078	76			
OP8	Between Groups	.717	2	.359	.579	.563
	Within Groups	45.802	74	.619		
	Total	46.519	76			
OP9	Between Groups	.218	2	.109	.126	.881
	Within Groups	63.860	74	.863		
	Total	64.078	76			
OP10	Between Groups	.205	2	.103	.078	.925
	Within Groups	97.924	74	1.323		
	Total	98.130	76			
OP11	Between Groups	.267	2	.134	.107	.899
	Within Groups	92.616	74	1.252		
	Total	92.883	76			
OP12	Between Groups	.295	2	.147	.161	.851
	Within Groups	67.653	74	.914		
	Total	67.948	76			
OP13	Between Groups	.162	2	.081	.146	.865
	Within Groups	41.085	74	.555		
	Total	41.247	76			
OP14	Between Groups	.588	2	.294	.339	.714
	Within Groups	63.347	73	.868		
	Total	63.934	75			
OP15	Between Groups	.272	2	.136	.210	.811
	Within Groups	47.254	73	.647		
	Total	47.526	75			
OP16	Between Groups	.587	2	.294	.374	.689
	Within Groups	57.347	73	.786		
	Total	57.934	75			
OP17	Between Groups	.513	2	.257	.257	.774
	Within Groups	72.908	73	.999		
	Total	73.421	75			
OP18	Between Groups	3.250	2	1.625	1.215	.303
	Within Groups	97.631	73	1.337		
	Total	100.882	75			

Table ANOVA analysis (F-value and significant value) of Operational risks based on type of organisation

- *Financial Risks*

		Sum of Squares	df	Mean Square	F	Sig.
F1	Between Groups	.822	2	.411	.405	.669
	Within Groups	75.126	74	1.015		
	Total	75.948	76			
F2	Between Groups	2.722	2	1.361	.845	.434
	Within Groups	119.226	74	1.611		
	Total	121.948	76			
F3	Between Groups	1.270	2	.635	.455	.636
	Within Groups	103.405	74	1.397		
	Total	104.675	76			
F4	Between Groups	1.995	2	.998	1.003	.372
	Within Groups	72.636	73	.995		
	Total	74.632	75			
F5	Between Groups	7.042	2	3.521	2.703	.074
	Within Groups	96.387	74	1.303		
	Total	103.429	76			
F6	Between Groups	5.208	2	2.604	1.916	.154
	Within Groups	100.584	74	1.359		
	Total	105.792	76			
F7	Between Groups	2.403	2	1.202	1.051	.355
	Within Groups	84.584	74	1.143		
	Total	86.987	76			
F8	Between Groups	1.147	2	.574	.443	.644
	Within Groups	95.736	74	1.294		
	Total	96.883	76			
F9	Between Groups	1.702	2	.851	.580	.563
	Within Groups	108.610	74	1.468		
	Total	110.312	76			
F10	Between Groups	4.260	2	2.130	1.978	.146
	Within Groups	79.688	74	1.077		
	Total	83.948	76			
F11	Between Groups	2.707	2	1.353	1.214	.303
	Within Groups	82.462	74	1.114		
	Total	85.169	76			
F12	Between Groups	5.830	2	2.915	2.725	.072
	Within Groups	79.157	74	1.070		
	Total	84.987	76			
F13	Between Groups	.629	2	.314	.244	.784
	Within Groups	95.164	74	1.286		
	Total	95.792	76			
F14	Between Groups	2.502	2	1.251	1.436	.244
	Within Groups	64.485	74	.871		
	Total	66.987	76			
F15	Between Groups	3.274	2	1.637	2.181	.120
	Within Groups	55.531	74	.750		
	Total	58.805	76			
F16	Between Groups	5.991	2	2.996	4.010	**.022**
	Within Groups	55.281	74	.747		
	Total	61.273	76			
F17	Between Groups	.463	2	.231	.458	.634
	Within Groups	37.355	74	.505		
	Total	37.818	76			
F18	Between Groups	1.760	2	.880	.867	.424
	Within Groups	75.123	74	1.015		
	Total	76.883	76			
F19	Between Groups	.151	2	.076	.106	.899
	Within Groups	52.550	74	.710		
	Total	52.701	76			
F20	Between Groups	.312	2	.156	.141	.868
	Within Groups	81.636	74	1.103		

	Total	81.948	76			
F21	Between Groups	1.638	2	.819	.521	.596
	Within Groups	116.310	74	1.572		
	Total	117.948	76			
F22	Between Groups	.007	2	.004	.003	.997
	Within Groups	84.980	74	1.148		
	Total	84.987	76			
F23	Between Groups	.521	2	.260	.186	.831
	Within Groups	103.843	74	1.403		
	Total	104.364	76			

Table ANOVA analysis (F-value and significant value) of Financial risks based on type of organisation

- ***Occupant dissatisfaction risks***

		Sum of Squares	df	Mean Square	F	Sig.
O1	Between Groups	1.170	2	.585	.908	.408
	Within Groups	47.687	74	.644		
	Total	48.857	76			
O2	Between Groups	2.002	2	1.001	1.270	.287
	Within Groups	58.310	74	.788		
	Total	60.312	76			
O3	Between Groups	1.530	2	.765	.905	.409
	Within Groups	62.548	74	.845		
	Total	64.078	76			
O4	Between Groups	2.847	2	1.424	1.609	.207
	Within Groups	65.465	74	.885		
	Total	68.312	76			
O5	Between Groups	3.604	2	1.802	1.528	.224
	Within Groups	87.279	74	1.179		
	Total	90.883	76			
O6	Between Groups	1.014	2	.507	.400	.672
	Within Groups	93.869	74	1.269		
	Total	94.883	76			

Table ANOVA analysis (F-value and significant value) of Occupant dissatisfaction risks based on type of organisation

- *Liability and Responsibility Risks*

		Sum of Squares	df	Mean Square	F	Sig.
LR1	Between Groups	4.476	2	2.238	1.824	.169
	Within Groups	90.796	74	1.227		
	Total	95.273	76			
LR12	Between Groups	1.048	2	.524	.422	.658
	Within Groups	91.939	74	1.242		
	Total	92.987	76			
LR3	Between Groups	2.660	2	1.330	1.023	.365
	Within Groups	96.223	74	1.300		
	Total	98.883	76			
LR4	Between Groups	.035	2	.017	.017	.983
	Within Groups	73.758	74	.997		
	Total	73.792	76			
LR5	Between Groups	1.560	2	.780	.699	.500
	Within Groups	82.570	74	1.116		
	Total	84.130	76			
LR6	Between Groups	2.169	2	1.085	1.029	.362
	Within Groups	77.961	74	1.054		
	Total	80.130	76			

Table ANOVA analysis (F-value and significant value) of Liability & Responsibility risks based on type of organisation

- *Reputational Risks*

		Sum of Squares	df	Mean Square	F	Sig.
R1	Between Groups	1.296	2	.648	.653	.523
	Within Groups	73.380	74	.992		
	Total	74.675	76			
R2	Between Groups	.191	2	.095	.093	.911
	Within Groups	75.758	74	1.024		
	Total	75.948	76			
R3	Between Groups	.921	2	.461	.349	.707
	Within Groups	97.754	74	1.321		
	Total	98.675	76			
R4	Between Groups	.372	2	.186	.162	.850
	Within Groups	84.796	74	1.146		
	Total	85.169	76			
R5	Between Groups	2.148	2	1.074	.784	.460
	Within Groups	101.385	74	1.370		
	Total	103.532	76			
R6	Between Groups	.845	2	.422	.322	.725
	Within Groups	96.948	74	1.310		
	Total	97.792	76			
R7	Between Groups	.866	2	.433	.453	.637
	Within Groups	70.666	74	.955		
	Total	71.532	76			
R8	Between Groups	.589	2	.295	.311	.734
	Within Groups	70.112	74	.947		
	Total	70.701	76			
R9	Between Groups	1.027	2	.513	.602	.550
	Within Groups	63.051	74	.852		
	Total	64.078	76			
R10	Between Groups	1.650	2	.825	.669	.515

	Within Groups	91.233	74	1.233		
	Total	92.883	76			
R11	Between Groups	.338	2	.169	.139	.870
	Within Groups	90.025	74	1.217		
	Total	90.364	76			
R12	Between Groups	2.145	2	1.072	1.086	.343
	Within Groups	73.102	74	.988		
	Total	75.247	76			
R13	Between Groups	2.208	2	1.104	1.624	.204
	Within Groups	50.311	74	.680		
	Total	52.519	76			
R14	Between Groups	1.029	2	.515	.597	.553
	Within Groups	63.776	74	.862		
	Total	64.805	76			
R15	Between Groups	.598	2	.299	.333	.718
	Within Groups	66.389	74	.897		
	Total	66.987	76			

Table ANOVA analysis (F-value and significant value) of Reputational risks based on type of organisation

- ***Regulatry Risks***

		Sum of Squares	df	Mean Square	F	Sig.
RE1	Between Groups	.179	2	.090	.111	.895
	Within Groups	59.769	74	.808		
	Total	59.948	76			
RE2	Between Groups	.962	2	.481	.609	.547
	Within Groups	58.492	74	.790		
	Total	59.455	76			
RE3	Between Groups	.009	2	.004	.006	.994
	Within Groups	56.667	74	.766		
	Total	56.675	76			
RE4	Between Groups	6.016	2	3.008	2.731	.072
	Within Groups	81.517	74	1.102		
	Total	87.532	76			
RE5	Between Groups	.313	2	.156	.254	.777
	Within Groups	45.635	74	.617		
	Total	45.948	76			
RE6	Between Groups	.157	2	.079	.130	.879
	Within Groups	44.830	74	.606		
	Total	44.987	76			
RE7	Between Groups	.266	2	.133	.204	.816
	Within Groups	48.254	74	.652		
	Total	48.519	76			

Table ANOVA analysis (F-value and significant value) of Regulation risks based on type of organisation

ANOVAs Rating Occurrence Time-Frame Based on Professional Roles

- *Physical Risks*

		Sum of Squares	df	Mean Square	F	Sig.
PH1	Between Groups	1.571	2	.785	.603	.550
	Within Groups	95.061	73	1.302		
	Total	96.632	75			
PH2	Between Groups	3.654	2	1.827	.930	.399
	Within Groups	143.451	73	1.965		
	Total	147.105	75			
PH3	Between Groups	2.312	2	1.156	1.005	.371
	Within Groups	83.938	73	1.150		
	Total	86.250	75			
PH4	Between Groups	1.501	2	.751	.417	.661
	Within Groups	131.486	73	1.801		
	Total	132.987	75			
PH5	Between Groups	1.535	2	.768	.542	.584
	Within Groups	103.346	73	1.416		
	Total	104.882	75			
PH6	Between Groups	6.880	2	3.440	2.843	.065
	Within Groups	88.318	73	1.210		
	Total	95.197	75			
PH7	Between Groups	.329	2	.164	.116	.891
	Within Groups	103.461	73	1.417		
	Total	103.789	75			
PH8	Between Groups	.097	2	.049	.061	.941
	Within Groups	58.061	73	.795		
	Total	58.158	75			
PH9	Between Groups	.707	2	.354	.475	.624
	Within Groups	54.280	73	.744		
	Total	54.987	75			
PH10	Between Groups	.114	2	.057	.076	.927
	Within Groups	54.518	73	.747		
	Total	54.632	75			
PH11	Between Groups	2.297	2	1.149	1.378	.259
	Within Groups	60.861	73	.834		
	Total	63.158	75			
PH12	Between Groups	1.433	2	.716	.415	.662
	Within Groups	125.975	73	1.726		
	Total	127.408	75			
PH13	Between Groups	1.665	2	.833	.440	.646
	Within Groups	138.071	73	1.891		
	Total	139.737	75			
PH14	Between Groups	2.685	2	1.343	.817	.446
	Within Groups	119.946	73	1.643		
	Total	122.632	75			
PH15	Between Groups	5.742	2	2.871	2.283	.109
	Within Groups	91.785	73	1.257		
	Total	97.526	75			
PH16	Between Groups	4.437	2	2.219	1.842	.166
	Within Groups	87.918	73	1.204		
	Total	92.355	75			
PH17	Between Groups	1.320	2	.660	.948	.392
	Within Groups	50.838	73	.696		
	Total	52.158	75			
PH18	Between Groups	2.241	2	1.121	1.145	.324
	Within Groups	71.443	73	.979		
	Total	73.684	75			
PH19	Between Groups	3.830	2	1.915	2.028	.139
	Within Groups	68.946	73	.944		

	Total	72.776	75			
PH20	Between Groups	4.060	2	2.030	2.226	.115
	Within Groups	66.571	73	.912		
	Total	70.632	75			
PH21	Between Groups	.937	2	.468	.406	.668
	Within Groups	84.261	73	1.154		
	Total	85.197	75			
PH22	Between Groups	.995	2	.497	.559	.574
	Within Groups	64.952	73	.890		
	Total	65.947	75			
PH23	Between Groups	3.457	2	1.728	2.329	.105
	Within Groups	54.175	73	.742		
	Total	57.632	75			
PH24	Between Groups	1.628	2	.814	.427	.654
	Within Groups	139.043	73	1.905		
	Total	140.671	75			
PH25	Between Groups	2.800	2	1.400	.700	.500
	Within Groups	145.976	73	2.000		
	Total	148.776	75			
PH26	Between Groups	.573	2	.287	.208	.813
	Within Groups	100.585	73	1.378		
	Total	101.158	75			
PH27	Between Groups	.409	2	.204	.207	.813
	Within Groups	71.946	73	.986		
	Total	72.355	75			
PH28	Between Groups	3.774	2	1.887	1.125	.330
	Within Groups	122.476	73	1.678		
	Total	126.250	75			
PH29	Between Groups	6.614	2	3.307	2.769	.069
	Within Groups	87.175	73	1.194		
	Total	93.789	75			
PH30	Between Groups	2.607	2	1.303	.903	.410
	Within Groups	105.327	73	1.443		
	Total	107.934	75			
PH31	Between Groups	6.437	2	3.219	2.961	.058
	Within Groups	79.352	73	1.087		
	Total	85.789	75			
PH32	Between Groups	.398	2	.199	.301	.741
	Within Groups	48.286	73	.661		
	Total	48.684	75			
PH33	Between Groups	.272	2	.136	.167	.847
	Within Groups	59.518	73	.815		
	Total	59.789	75			
PH34	Between Groups	4.958	2	2.479	1.627	.203
	Within Groups	111.200	73	1.523		
	Total	116.158	75			
PH35	Between Groups	.921	2	.461	.242	.786
	Within Groups	139.013	73	1.904		
	Total	139.934	75			
PH36	Between Groups	3.612	2	1.806	2.037	.138
	Within Groups	64.743	73	.887		
	Total	68.355	75			
PH37	Between Groups	2.314	2	1.157	1.131	.328
	Within Groups	73.686	72	1.023		
	Total	76.000	74			

Table ANOVA analysis (F-value and significant value) of physical risks based on type professional roles

- *Operational Risks*

		Sum of Squares	df	Mean Square	F	Sig.
OP1	Between Groups	.179	2	.089	.232	.793
	Within Groups	28.071	73	.385		
	Total	28.250	75			
OP2	Between Groups	.079	2	.040	.230	.795
	Within Groups	12.605	73	.173		
	Total	12.684	75			
OP3	Between Groups	.190	2	.095	.375	.689
	Within Groups	18.546	73	.254		
	Total	18.737	75			
OP4	Between Groups	.100	2	.050	.072	.931
	Within Groups	50.571	73	.693		
	Total	50.671	75			
OP5	Between Groups	.988	2	.494	1.338	.269
	Within Groups	26.946	73	.369		
	Total	27.934	75			
OP6	Between Groups	2.440	2	1.220	2.317	.106
	Within Groups	38.442	73	.527		
	Total	40.882	75			
OP7	Between Groups	.730	2	.365	.645	.528
	Within Groups	41.310	73	.566		
	Total	42.039	75			
OP8	Between Groups	.401	2	.201	.330	.720
	Within Groups	44.375	73	.608		
	Total	44.776	75			
OP9	Between Groups	.230	2	.115	.139	.871
	Within Groups	60.546	73	.829		
	Total	60.776	75			
OP10	Between Groups	1.823	2	.912	.717	.492
	Within Groups	92.861	73	1.272		
	Total	94.684	75			
OP11	Between Groups	3.368	2	1.684	1.436	.245
	Within Groups	85.619	73	1.173		
	Total	88.987	75			
OP12	Between Groups	1.215	2	.608	.674	.513
	Within Groups	65.771	73	.901		
	Total	66.987	75			
OP13	Between Groups	1.726	2	.863	1.605	.208
	Within Groups	39.261	73	.538		
	Total	40.987	75			
OP14	Between Groups	3.413	2	1.707	2.158	.123
	Within Groups	56.933	72	.791		
	Total	60.347	74			
OP15	Between Groups	.987	2	.493	.763	.470
	Within Groups	46.533	72	.646		
	Total	47.520	74			
OP16	Between Groups	3.012	2	1.506	1.975	.146
	Within Groups	54.908	72	.763		
	Total	57.920	74			
OP17	Between Groups	2.278	2	1.139	1.153	.321
	Within Groups	71.108	72	.988		
	Total	73.387	74			
OP18	Between Groups	4.697	2	2.348	1.803	.172
	Within Groups	93.783	72	1.303		
	Total	98.480	74			

Table ANOVA analysis (F-value and significant value) of Operational risks based on professional roles

- *Financial Risks*

		Sum of Squares	df	Mean Square	F	Sig.
F1	Between Groups	2.759	2	1.380	1.447	.242
	Within Groups	69.596	73	.953		
	Total	72.355	75			
F2	Between Groups	.570	2	.285	.176	.839
	Within Groups	117.786	73	1.614		
	Total	118.355	75			
F3	Between Groups	1.542	2	.771	.552	.578
	Within Groups	101.985	73	1.397		
	Total	103.526	75			
F4	Between Groups	.053	2	.027	.026	.975
	Within Groups	74.533	72	1.035		
	Total	74.587	74			
F5	Between Groups	.997	2	.498	.360	.699
	Within Groups	101.108	73	1.385		
	Total	102.105	75			
F6	Between Groups	3.362	2	1.681	1.211	.304
	Within Groups	101.310	73	1.388		
	Total	104.671	75			
F7	Between Groups	1.048	2	.524	.450	.639
	Within Groups	84.952	73	1.164		
	Total	86.000	75			
F8	Between Groups	.725	2	.362	.288	.751
	Within Groups	91.946	73	1.260		
	Total	92.671	75			
F9	Between Groups	.324	2	.162	.109	.897
	Within Groups	108.413	73	1.485		
	Total	108.737	75			
F10	Between Groups	3.220	2	1.610	1.474	.236
	Within Groups	79.767	73	1.093		
	Total	82.987	75			
F11	Between Groups	.628	2	.314	.274	.761
	Within Groups	83.727	73	1.147		
	Total	84.355	75			
F12	Between Groups	3.300	2	1.650	1.493	.232
	Within Groups	80.700	73	1.105		
	Total	84.000	75			
F13	Between Groups	.537	2	.269	.206	.814
	Within Groups	95.252	73	1.305		
	Total	95.789	75			
F14	Between Groups	1.679	2	.839	.938	.396
	Within Groups	65.308	73	.895		
	Total	66.987	75			
F15	Between Groups	.030	2	.015	.019	.982
	Within Groups	58.746	73	.805		
	Total	58.776	75			
F16	Between Groups	.626	2	.313	.377	.687
	Within Groups	60.571	73	.830		
	Total	61.197	75			
F17	Between Groups	.189	2	.094	.185	.831
	Within Groups	37.219	73	.510		
	Total	37.408	75			
F18	Between Groups	3.164	2	1.582	1.566	.216
	Within Groups	73.718	73	1.010		
	Total	76.882	75			
F19	Between Groups	1.384	2	.692	.991	.376
	Within Groups	50.971	73	.698		
	Total	52.355	75			
F20	Between Groups	2.943	2	1.471	1.359	.263
	Within Groups	79.005	73	1.082		

	Total	81.947	75			
F21	Between Groups	2.791	2	1.396	.885	.417
	Within Groups	115.143	73	1.577		
	Total	117.934	75			
F22	Between Groups	.669	2	.334	.290	.749
	Within Groups	84.318	73	1.155		
	Total	84.987	75			
F23	Between Groups	.246	2	.123	.086	.918
	Within Groups	104.110	73	1.426		
	Total	104.355	75			

Table ANOVA analysis (F-value and significant value) of Financial risks based on professional roles

- ***Occupant dissatisfaction risks***

		Sum of Squares	df	Mean Square	F	Sig.
O1	Between Groups	.643	2	.322	.509	.603
	Within Groups	46.146	73	.632		
	Total	46.789	75			
O2	Between Groups	3.173	2	1.587	2.033	.138
	Within Groups	56.985	73	.781		
	Total	60.158	75			
O3	Between Groups	.779	2	.389	.449	.640
	Within Groups	63.261	73	.867		
	Total	64.039	75			
O4	Between Groups	.194	2	.097	.105	.901
	Within Groups	67.543	73	.925		
	Total	67.737	75			
O5	Between Groups	1.468	2	.734	.605	.549
	Within Groups	88.480	73	1.212		
	Total	89.947	75			
O6	Between Groups	2.456	2	1.228	.982	.380
	Within Groups	91.333	73	1.251		
	Total	93.789	75			

Table ANOVA analysis (F-value and significant value) of Occupant dissatisfaction risks based professional roles

- *Liability and Responsibility Risks*

		Sum of Squares	df	Mean Square	F	Sig.
LR1	Between Groups	1.822	2	.911	.724	.488
	Within Groups	91.810	73	1.258		
	Total	93.632	75			
LR12	Between Groups	.367	2	.183	.146	.864
	Within Groups	91.633	73	1.255		
	Total	92.000	75			
LR3	Between Groups	4.729	2	2.364	1.855	.164
	Within Groups	93.061	73	1.275		
	Total	97.789	75			
LR4	Between Groups	11.643	2	5.822	6.838	**.002**
	Within Groups	62.146	73	.851		
	Total	73.789	75			
LR5	Between Groups	3.653	2	1.826	1.657	.198
	Within Groups	80.452	73	1.102		
	Total	84.105	75			
LR6	Between Groups	2.747	2	1.374	1.308	.277
	Within Groups	76.661	73	1.050		
	Total	79.408	75			

Table ANOVA analysis (F-value and significant value) of Liability & Responsibility risks based on professional roles

- *Reputational Risks*

		Sum of Squares	df	Mean Square	F	Sig.
R1	Between Groups	6.913	2	3.457	3.773	.028
	Within Groups	66.876	73	.916		
	Total	73.789	75			
R2	Between Groups	.279	2	.139	.136	.873
	Within Groups	74.708	73	1.023		
	Total	74.987	75			
R3	Between Groups	1.312	2	.656	.499	.609
	Within Groups	95.886	73	1.314		
	Total	97.197	75			
R4	Between Groups	.416	2	.208	.182	.834
	Within Groups	83.518	73	1.144		
	Total	83.934	75			
R5	Between Groups	2.026	2	1.013	.729	.486
	Within Groups	101.500	73	1.390		
	Total	103.526	75			
R6	Between Groups	.885	2	.443	.337	.715
	Within Groups	95.786	73	1.312		
	Total	96.671	75			
R7	Between Groups	2.953	2	1.477	1.592	.211
	Within Groups	67.718	73	.928		
	Total	70.671	75			
R8	Between Groups	.948	2	.474	.502	.607
	Within Groups	68.986	73	.945		
	Total	69.934	75			
R9	Between Groups	.560	2	.280	.325	.723

	Within Groups	62.861	73	.861		
	Total	63.421	75			
R10	Between Groups	1.872	2	.936	.760	.471
	Within Groups	89.918	73	1.232		
	Total	91.789	75			
R11	Between Groups	.012	2	.006	.005	.995
	Within Groups	90.343	73	1.238		
	Total	90.355	75			
R12	Between Groups	.688	2	.344	.337	.715
	Within Groups	74.510	73	1.021		
	Total	75.197	75			
R13	Between Groups	.983	2	.492	.725	.488
	Within Groups	49.543	73	.679		
	Total	50.526	75			
R14	Between Groups	.399	2	.199	.226	.798
	Within Groups	64.338	73	.881		
	Total	64.737	75			
R15	Between Groups	1.082	2	.541	.599	.552
	Within Groups	65.905	73	.903		
	Total	66.987	75			

Table ANOVA analysis (F-value and significant value) of Reputational risks based on professional roles

- ***Regulatory Risks***

		Sum of Squares	df	Mean Square	F	Sig.
RE1	Between Groups	.538	2	.269	.330	.720
	Within Groups	59.410	73	.814		
	Total	59.947	75			
RE2	Between Groups	5.303	2	2.652	3.577	**.033**
	Within Groups	54.118	73	.741		
	Total	59.421	75			
RE3	Between Groups	.191	2	.096	.124	.884
	Within Groups	56.480	73	.774		
	Total	56.671	75			
RE4	Between Groups	2.866	2	1.433	1.248	.293
	Within Groups	83.805	73	1.148		
	Total	86.671	75			
RE5	Between Groups	.416	2	.208	.334	.717
	Within Groups	45.518	73	.624		
	Total	45.934	75			
RE6	Between Groups	.012	2	.006	.010	.990
	Within Groups	44.975	73	.616		
	Total	44.987	75			
RE7	Between Groups	.983	2	.492	.788	.458
	Within Groups	45.543	73	.624		
	Total	46.526	75			

Table ANOVA analysis (F-value and significant value) of Regulation risks based on professional roles

Climate Change Risk Management

- *ANOVAs Rating Based on the Type of Organisation*

		Sum of Squares	df	Mean Square	F	Sig.
RM1	Between Groups	.020	2	.010	.022	.978
	Within Groups	33.275	75	.444		
	Total	33.295	77			
RM2	Between Groups	.577	2	.288	.558	.575
	Within Groups	38.757	75	.517		
	Total	39.333	77			
RM3	Between Groups	.322	2	.161	.332	.719
	Within Groups	36.396	75	.485		
	Total	36.718	77			
RM4	Between Groups	.250	2	.125	.219	.804
	Within Groups	42.929	75	.572		
	Total	43.179	77			
RM5	Between Groups	1.574	2	.787	1.717	.187
	Within Groups	34.375	75	.458		
	Total	35.949	77			
RM6	Between Groups	.830	2	.415	.812	.448
	Within Groups	38.349	75	.511		
	Total	39.179	77			
RM7	Between Groups	.711	2	.355	.559	.574
	Within Groups	47.661	75	.635		
	Total	48.372	77			
RM8	Between Groups	1.066	2	.533	.735	.483
	Within Groups	54.382	75	.725		
	Total	55.449	77			
RM9	Between Groups	.023	2	.011	.016	.984
	Within Groups	52.695	75	.703		
	Total	52.718	77			
RM10	Between Groups	.590	2	.295	.376	.688
	Within Groups	58.897	75	.785		
	Total	59.487	77			
RM11	Between Groups	1.517	2	.758	1.375	.259
	Within Groups	41.355	75	.551		
	Total	42.872	77			
RM12	Between Groups	.023	2	.012	.015	.985
	Within Groups	56.861	75	.758		
	Total	56.885	77			
RM13	Between Groups	5.710	2	2.855	4.099	.020
	Within Groups	52.239	75	.697		
	Total	57.949	77			
RM14	Between Groups	.441	2	.221	.308	.736
	Within Groups	53.777	75	.717		
	Total	54.218	77			
RM15	Between Groups	1.826	2	.913	1.479	.234
	Within Groups	46.290	75	.617		
	Total	48.115	77			
RM16	Between Groups	2.074	2	1.037	1.419	.248
	Within Groups	54.810	75	.731		
	Total	56.885	77			

RM17	Between Groups	3.611	2	1.806	2.777	.069
	Within Groups	48.761	75	.650		
	Total	52.372	77			
RM18	Between Groups	1.108	2	.554	.905	.409
	Within Groups	45.880	75	.612		
	Total	46.987	77			
RM19	Between Groups	.394	2	.197	.325	.723
	Within Groups	45.401	75	.605		
	Total	45.795	77			
RM20	Between Groups	1.804	2	.902	1.617	.205
	Within Groups	41.849	75	.558		
	Total	43.654	77			
RM21	Between Groups	1.612	2	.806	1.104	.337
	Within Groups	54.760	75	.730		
	Total	56.372	77			
RM22	Between Groups	8.441	2	4.220	5.255	.007
	Within Groups	60.239	75	.803		
	Total	68.679	77			
RM23	Between Groups	1.001	2	.500	.767	.468
	Within Groups	48.948	75	.653		
	Total	49.949	77			
RM24	Between Groups	3.476	2	1.738	2.190	.119
	Within Groups	59.511	75	.793		
	Total	62.987	77			

Table ANOVA analysis (F-value and significant value) of CCRM factors based on type of organisation

- *ANOVAs Rating Based on the Professional Role*

		Sum of Squares	df	Mean Square	F	Sig.
RM1	Between Groups	3.759	2	1.879	4.716	.012
	Within Groups	29.488	74	.398		
	Total	33.247	76			
RM2	Between Groups	4.724	2	2.362	5.067	.009
	Within Groups	34.497	74	.466		
	Total	39.221	76			
RM3	Between Groups	1.469	2	.735	1.544	.220
	Within Groups	35.206	74	.476		
	Total	36.675	76			
RM4	Between Groups	1.851	2	.925	1.657	.198
	Within Groups	41.318	74	.558		
	Total	43.169	76			
RM5	Between Groups	2.751	2	1.376	3.066	.053
	Within Groups	33.197	74	.449		
	Total	35.948	76			
RM6	Between Groups	6.169	2	3.084	6.917	.002
	Within Groups	33.000	74	.446		
	Total	39.169	76			
RM7	Between Groups	2.291	2	1.145	1.840	.166
	Within Groups	46.073	74	.623		
	Total	48.364	76			
RM8	Between Groups	5.041	2	2.520	3.701	.029
	Within Groups	50.388	74	.681		
	Total	55.429	76			
RM9	Between Groups	5.123	2	2.562	4.037	.022
	Within Groups	46.955	74	.635		
	Total	52.078	76			
RM10	Between Groups	3.266	2	1.633	2.158	.123
	Within Groups	55.981	74	.757		
	Total	59.247	76			
RM11	Between Groups	2.824	2	1.412	2.646	.078
	Within Groups	39.488	74	.534		
	Total	42.312	76			
RM12	Between Groups	4.566	2	2.283	3.298	.042
	Within Groups	51.227	74	.692		
	Total	55.792	76			
RM13	Between Groups	2.533	2	1.267	1.704	.189
	Within Groups	54.999	74	.743		
	Total	57.532	76			
RM14	Between Groups	2.872	2	1.436	2.075	.133
	Within Groups	51.206	74	.692		
	Total	54.078	76			
RM15	Between Groups	1.451	2	.726	1.152	.322
	Within Groups	46.627	74	.630		
	Total	48.078	76			
RM16	Between Groups	3.211	2	1.606	2.214	.116
	Within Groups	53.672	74	.725		
	Total	56.883	76			
RM17	Between Groups	2.124	2	1.062	1.566	.216
	Within Groups	50.188	74	.678		
	Total	52.312	76			
RM18	Between Groups	4.588	2	2.294	4.004	.022
	Within Groups	42.399	74	.573		
	Total	46.987	76			
RM19	Between Groups	3.177	2	1.589	2.819	.066
	Within Groups	41.706	74	.564		
	Total	44.883	76			
RM20	Between Groups	.926	2	.463	.805	.451

	Within Groups	42.606	74	.576		
	Total	43.532	76			
RM21	Between Groups	1.130	2	.565	.757	.473
	Within Groups	55.233	74	.746		
	Total	56.364	76			
RM22	Between Groups	2.995	2	1.498	1.710	.188
	Within Groups	64.797	74	.876		
	Total	67.792	76			
RM23	Between Groups	3.682	2	1.841	2.945	.059
	Within Groups	46.266	74	.625		
	Total	49.948	76			
RM24	Between Groups	1.948	2	.974	1.181	.313
	Within Groups	61.039	74	.825		
	Total	62.987	76			

Table ANOVA analysis (F-value and significant value) of CCRM factors based on professional roles

Table 1: Descriptive statistics for physical risk

R.F Code	Risk Factors	Percent of scores (%)				Mean	Median	St. Deviation	Category Rank
		Not all%	0-5years %	5-10years%	Over 10years%				
		1	2	3	4				
PH1	Rapid asset deterioration	**16.7**	**7.8**	**15.6**	**59.7**	2.18	3.00	1.155	*34*
PH2	Potential for increased odour problems	**37.2**	**5.2**	**9.1**	**48.1**	1.68	2.00	1.400	*8*
PH3	Reduced asset life	**15.4**	**3.9**	**23.4**	**57.1**	2.22	3.00	1.096	*35*
PH4	Disposal of debris including hazardous materials (from windstorms)	**29.5**	**1.3**	**11.7**	**57.1**	1.96	3.00	1.342	*23*
PH5	Increased fire risks	**18.2**	**15.6**	**16.9**	**49.4**	1.97	2.00	1.181	*25*
PH6	Scour to structures (from intense rainfall)	**15.6**	**5.2**	**14.3**	**64.9**	2.29	3.00	1.122	*36*
PH7	Cracking or melting of pavements	**19.5**	**6.5**	**22.1**	**51.9**	2.06	3.00	1.174	*30*
PH8	Cracking of building fabric	**6.5**	**6.5**	**27.3**	**59.7**	2.40	3.00	.877	*37*
PH9	Potential need for retrofitting mechanical ventilation	**3.9**	**24.7**	**40.3**	**31.2**	1.99	2.00	.851	*26*
PH10	Increased capital expenditures due to physical risks	**3.9**	**36.4**	**35.1**	**24.1**	1.81	2.00	.859	*14*
PH11	Reliability of mechanical and electrical services in buildings	**7.8**	**27.3**	**35.1**	**29.9**	1.87	2.00	.937	*18*
PH12	Increasing subsidence and heave movement	**28.2**	**5.2**	**16.9**	**49.4**	1.87	2.00	1.301	*19*
PH13	Damage to building foundation due to subsidence and heave movement	**33.8**	**3.9**	**13.0**	**49.4**	1.78	2.00	1.363	*12*
PH14	Damage to building facades due to subsidence and heave movement	**28.2**	**6.5**	**20.8**	**44.2**	1.81	2.00	1.278	*16*
PH15	Increasing soil shrinking and swelling	**18.2**	**5.2**	**26**	**50.6**	2.09	3.00	1.138	*31*
PH16	Damage to underground services	**15.6**	**9.1**	**24.7**	**50.6**	2.10	3.00	1.107	*32*
PH17	Surface water flooding	**5.2**	**45.5**	**32.5**	**16.9**	1.61	1.00	.830	*3*
PH18	Groundwater water flooding (from rising groundwater)	**14.3**	**29.9**	**32.5**	**23.4**	1.65	2.00	.997	*6*
PH19	Water ingress to facades	**10.4**	**29.9**	**28.6**	**31.2**	1.81	2.00	1.001	*15*
PH20	Water ingress to roofs	**7.8**	**39**	**22.1**	**31.2**	1.77	2.00	.985	*10*
PH21	Inundation of basement and ground floor	**13**	**29.9**	**22.1**	**35.1**	1.79	2.00	1.068	*13*
PH22	Vulnerability of services and plant	**6.5**	**24.7**	**32.5**	**36.4**	1.99	2.00	.939	*27*
PH23	Increase in the cost of materials supplies	**3.9**	**48.1**	**23.4**	**24.7**	1.69	1.00	.892	*9*
PH24	Saline water intrusion	**44.2**	**2.6**	**16.9**	**36.4**	1.45	2.00	1.372	*1*
PH25	Corrosive saline atmospheric exposure	**40.3**	**1.3**	**11.7**	**46.8**	1.65	2.00	1.412	*7*
PH26	Increase of acid rain weathering on building fabric	**19.5**	**2.6**	**26**	**51.9**	2.10	3.00	1.154	*33*
PH27	Increase of defective building elements due to unforeseen weather conditions	**10.4**	**15.6**	**31.2**	**42.9**	2.06	2.00	1.004	*29*
PH28	Extreme exposure of building shell to dust	**31.2**	**3.9**	**22.1**	**42.9**	1.77	2.00	1.297	*11*
PH29	Increase of latent defect problems	**18.2**	**13**	**27.3**	**41.6**	1.92	2.00	1.133	*21*
PH30	Damage due to high snow load on buildings	**20.8**	**14.3**	**19.5**	**45.5**	1.90	2.00	1.199	*20*
PH31	Damage to building assets from frost/snow	**13**	**19.5**	**26**	**41.6**	1.96	2.00	1.069	*22*
PH32	Increase of damp, condensation and mould problems in buildings	**1.3**	**35.1**	**39**	**24.7**	1.87	2.00	.801	*17*
PH33	Erosion of historic building fabric	**3.9**	**24.7**	**32.5**	**39**	2.06	2.00	.894	*28*
PH34	Lightning strike damage to buildings during storms	**28.6**	**16.9**	**18.2**	**36.4**	1.62	2.00	1.246	*4*
PH35	Slope instability	**36.4**	**7.8**	**11.7**	**44.2**	1.64	2.00	1.366	*5*
PH36	Insufficient roof drainage in storms	**10.4**	**41.6**	**26**	**22.1**	1.60	1.00	.950	*2*
PH37	Decreased durability and performance of materials	**11.8**	**18.4**	**30.3**	**39.5**	1.97	2.00	1.032	*24*

Table 2: Descriptive statistics for operational risks

R.F Code	Risk Factors	Percent of scores (%) Not all% 1	0-5years% 2	5-10years % 3	Over 10years % 4	Mean	Median	St. Deviation	Category Rank
OP1	Increase in energy use	**2.6**	**75.3**	**14.3**	**7.8**	1.27	1.00	.641	*3*
OP2	Higher energy prices	**-**	**89.6**	**7.8**	**2.6**	1.13	1.00	.409	*1*
OP3	Increasing water costs	**-**	**76.6**	**20.8**	**2.6**	1.26	1.00	.497	*2*
OP4	Water use restriction	**5.2**	**48.1**	**31.2**	**15.6**	1.57	1.00	.818	*8*
OP5	Higher costs of repair	**-**	**67.5**	**24.7**	**7.8**	1.40	1.00	.634	*4*
OP6	Increased maintenance regimes	**-**	**59.7**	**26**	**14.3**	1.55	1.00	.735	*7*
OP7	Electricity brownouts and blackouts	**1.3**	**35.1**	**45.5**	**18.2**	1.81	2.00	.744	*10*
OP8	Increased reliance on mechanical cooling	**3.9**	**39**	**41.6**	**15.6**	1.69	2.00	.782	*9*
OP9	More frequent mechanical breakdowns	**7.8**	**29.9**	**36.4**	**26**	1.81	2.00	.918	*11*
OP10	Reduced access to infrastructure	**15.6**	**15.6**	**26**	**42.9**	1.96	2.00	1.106	*17*
OP11	Reduced access to facilities	**19.5**	**14.3**	**28.6**	**37.7**	1.84	2.00	1.136	*13*
OP12	Increased downtime	**6.5**	**23.4**	**31.2**	**39**	2.03	2.00	.946	*18*
OP13	Increase in the cost of waste water discharge	**1.3**	**59.7**	**26**	**13**	1.51	1.00	.737	*5*
OP14	Temporary closure of facilities	**6.6**	**28.9**	**34.2**	**30.3**	1.88	2.00	.923	*15*
OP15	Increased costs due to alternative short-term supplies	**2.6**	**27.6**	**44.7**	**25**	1.92	2.00	.796	*16*
OP16	Interruption of supply chain	**5.3**	**28.9**	**38.2**	**27.6**	1.88	2.00	.879	*14*
OP17	Disruptions of telecommunication services	**9.2**	**31.6**	**27.6**	**31.6**	1.82	2.00	.989	*12*
OP18	Increased slips and falls	**23.7**	**28.9**	**17.1**	**30.3**	1.54	1.00	1.160	*6*

Table 3: Descriptive statistics for financial risk

R.E Code	Risks Factors	Percent of scores (%) Not all% 1	0-5years % 2	5-10years% 3	Over 10years% 4	Mean	Median	St. Deviation	Category Rank
F1	Lower profit margins	**9.1**	**28.6**	**27.3**	**35.1**	1.88	2.00	1.000	*7*
F2	Unable to repay debts	**24.7**	**11.7**	**14.3**	**49.4**	1.88	2.00	1.267	*9*
F3	Equity growth not realised	**19.5**	**13**	**22.1**	**45.5**	1.94	2.00	1.174	*11*
F4	Increase in administrative expenses	**7.9**	**38.2**	**21.1**	**32.9**	1.79	2.00	.998	*5*
F5	Reduced ability to secure funding for adaptation due to negative property valuation	**19.5**	**13**	**20.8**	**46.8**	1.95	2.00	1.180	*13*
F6	Reduced ability to secure funding for refurbishment due to negative property valuation	**19.5**	**16.9**	**22.1**	**41.6**	1.86	2.00	1.167	*6*
F7	Fall in value of mal-adapted properties	**13**	**16.9**	**26**	**44.2**	2.01	2.00	1.070	*19*
F8	Loss of income from properties	**14.3**	**16.9**	**20.8**	**47.1**	2.04	2.00	1.129	*21*
F9	Businesses become less competitive	**23.4**	**16.9**	**20.8**	**39**	1.75	2.00	1.205	*4*
F10	Properties may not be saleable because of climate change compliance	**13**	**14.3**	**29.9**	**42.9**	2.03	2.00	1.051	*20*
F11	Negative property valuation due to structural damage	**13**	**11.7**	**27.3**	**48.1**	2.10	2.00	1.059	*22*

F12	Negative property valuation due to services damage or compliance with climate change legislation	**14.3**	**11.7**	**32.5**	**41.6**	2.01	2.00	1.057	*17*
F13	Loss of revenue due to customer behaviour	**16.9**	**14.3**	**26**	**42.9**	1.95	2.00	1.123	*12*
F14	Changing patterns of consumer demand	**7.8**	**20.8**	**36.4**	**35.1**	1.99	2.00	.939	*16*
F15	Affordability of property rent/development	**5.2**	**15.6**	**36.4**	**42.9**	2.17	2.00	.880	*23*
F16	Increase costs to purchase	**5.2**	**41.6**	**28.6**	**24.7**	1.73	2.00	.898	*3*
F17	Increased insurance excess	**1.3**	**45.5**	**41.6**	**11.7**	1.64	2.00	.705	*2*
F18	Additional expense in insuring buildings prone to the urban heat island effect	**11.7**	**16.9**	**35.1**	**36.4**	1.96	2.00	1.006	*14*
F19	Additional expense in insuring buildings in flood risk zones	**6.5**	**44.2**	**33.8**	**15.6**	1.58	1.00	.833	*1*
F20	Increases in areas prone to soil heave/shrinkage	**13**	**15.6**	**32.5**	**39**	1.97	2.00	1.038	*15*
F21	Un-insurability due to climate change	**24.7**	**9.1**	**19.5**	**46.8**	1.88	2.00	1.246	*8*
F22	Affordability of property insurance	**11.7**	**19.5**	**24.7**	**44.2**	2.01	2.00	1.057	*18*
F23	Availability of property insurance	**18.2**	**18.2**	**18.2**	**45.5**	1.91	2.00	1.172	*10*

Table 4: Descriptive statistics for 0ccupant dissatisfaction

R.E Code	**Risks Factors**	**Percent of scores (%)**				**Mean**	**Median**	**St. Deviation**	**Category Rank**
		Not all%	0-5years %	5-10years %	Over 10years%				
		1	**2**	**3**	**4**				
O1	Thermal discomfort	**3.9**	**50.6**	**29.9**	**15.6**	1.57	1.00	.802	*1*
O2	Loss of productivity	**7.8**	**42.9**	**29.9**	**19.5**	1.61	1.00	.891	*2*
O3	Heat related health risks	**6.5**	**33.8**	**32.5**	**27.3**	1.81	2.00	.918	*3*
O4	Usability of Buildings become impaired	**3.9**	**22.1**	**20.8**	**51.9**	2.25	3.00	.948	*6*
O5	Business continuity impaired	**13**	**18.2**	**20.8**	**48.1**	2.04	2.00	1.094	*5*
O6	Occupant litigation	**18.2**	**9.1**	**31.2**	**41.6**	1.96	2.00	1.117	*4*

Table 5: Descriptive statistics for liability and responsibility

R.E Code	**Risks Factors**	**Percent of scores (%)**				**Mean**	**Median**	**St. Deviation**	**Category Rank**
		Not all%	0-5years %	5-10years %	Over 10years%				
		1	**2**	**3**	**4**				
LR1	Increase of recourse action against professional advisors	**19.5**	**20.8**	**27.3**	**32.5**	1.73	2.00	1.120	*1*
LR2	Buildings dangerous to health as a result of high temperature	**15.6**	**13**	**26**	**45.5**	2.01	2.00	1.106	*3*
LR3	Increase of claims in contract or tort because buildings designed, or operated in a way that has insufficient regard to the reasonably anticipated impacts of climate change	**18.2**	**11.7**	**26**	**44.2**	1.96	2.00	1.141	*2*
LR4	Increasing environmental litigation	**9.1**	**18.2**	**31.2**	**41.6**	2.05	2.00	.985	*4*
LR5	Increasing decommissioning liabilities	**11.7**	**13**	**23.4**	**51.9**	2.16	3.00	1.052	*6*
LR6	Professionals (advisers, designers, owners, tenant, insurers) will bear the responsibility of mal-adapted new buildings	**11.7**	**10.4**	**28.6**	**49.4**	2.16	2.00	1.027	*5*

Table 6: Descriptive statistics for Reputational risks

R.E Code	Risks Factors	Percent of scores (%) Not all%	0-5years %	5-10years%	Over 10years%	Mean	Median	St. Deviation	Category Rank
		1	2	3	4				
R1	Loss of economic benefits	**9.1**	**16.9**	**33.8**	**40.3**	2.06	2.00	.991	*12*
R2	Negative impact on corporate social responsibility	**9.1**	**19.5**	**32.5**	**39**	2.03	2.00	1.000	*11*
R3	Market differentiation	**19.5**	**16.9**	**29.9**	**33.8**	1.79	2.00	1.139	*4*
R4	Loss of organisations' sustainability credential	**13**	**22.1**	**27.3**	**37.7**	1.90	2.00	1.059	*5*
R5	Loss of investors	**18.2**	**16.9**	**19.5**	**45.5**	1.92	2.00	1.167	*7*
R6	Lower staff retention and productivity due to building usability	**16.9**	**15.6**	**23.4**	**44.2**	1.95	2.00	1.134	*8*
R7	Higher economic risks	**7.8**	**19.5**	**29.9**	**42.9**	2.08	2.00	.970	*13*
R8	Higher legal risks	**7.8**	**16.9**	**29.9**	**45.5**	2.13	2.00	.965	*14*
R9	Higher liabilities risks	**5.2**	**18.2**	**28.6**	**48.1**	2.19	2.00	.918	*15*
R10	Loss of potential customers due to business interruption	**13**	**23.4**	**18.2**	**45.5**	1.96	2.00	1.106	*9*
R11	Negative impact on organisations' brand and reputation	**11.7**	**28.6**	**16.9**	**42.9**	1.91	2.00	1.090	*6*
R12	Increased sick days	**9.1**	**35.1**	**24.7**	**31.2**	1.78	2.00	.995	*3*
R13	Increased carbon emissions	**2.6**	**54.5**	**23.4**	**19.5**	1.60	1.00	.831	*1*
R14	Increased level of staff stress	**6.5**	**39**	**28.6**	**26**	1.74	2.00	.923	*2*
R15	Negative impact on organisations reputation from being seen as a contributor to climate change	**7.8**	**19.5**	**36.4**	**36.4**	2.01	2.00	.939	*10*

Table 7: Descriptive statistics for Regulation risks

R.E Code	Risks Factors	Percent of scores (%) Not all%	0-5years %	5-10years%	Over 10years%	Mean	Median	St. Deviation	Category Rank
		1	2	3	4				
RE1	Stringent regulation in relation to water stress	**3.9**	**28.6**	**33.8**	**33.8**	1.97	2.00	.888	*4*
RE2	Stringent regulation in relation to flood stress	**7.8**	**26**	**42.9**	**23.4**	1.82	2.00	.884	*2*
RE3	Stringent regulation in relation to overheating stress	**6.5**	**14.3**	**45.5**	**33.8**	2.06	2.00	.864	*7*
RE4	Stringent regulation in relation to windstorms stress	**14.3**	**10.4**	**28.6**	**46.8**	2.08	2.00	1.073	*8*
RE5	Strict limits on greenhouse gas emissions	**1.3**	**32.5**	**42.9**	**23.4**	1.88	2.00	.778	*3*
RE6	Strict limits on greenhouse gas emissions	**1.3**	**26**	**45.5**	**27.3**	1.99	2.00	.769	*5*
RE7	Uncertainty of pending legislation on climate change	**1.3**	**55.8**	**24.7**	**18.2**	1.60	1.00	.799	*1*