Formulating an FM strategy for climate change mitigation and adaptation of commercial built assets

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DECLARATION

"I certify that this work has not been accepted in substance for any degree, and is not concurrently being submitted for any degree other than that of Doctor of Philosophy being studied at the University of Greenwich. I also declare that this work is the result of my own investigations except where otherwise identified by references and that I have not plagiarised the work of others".

Sign…………………………………..**(Student)**

Date…………………………………..

Sign …………………………………**(Supervisor)**

Date……………………………………

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ABSTRACT

As per the UKCIP 09 climate change projections the United Kingdom is very likely to experience increased sea level rise, increased winter rainfall, heat waves and an increase in frequency and severity of extreme weather events. Such inevitable impacts of climate change will require adaptation measures to be implemented for the management of existing commercial built assets if they are to continue to fulfil their primary function and support every organisation's business operations. However, it is not clear as to how far adaptation solutions are effectively integrated into facilities or built-asset management planning?

While seeking the answers to above questions, this thesis develops an approach for facilities and built-asset management, which will improve the resilience of existing commercial built assets to future physical climate-change impacts. The study undertakes a participatory study with a large commercial organisation and a questionnaire survey of UK facilities managers. The participatory study involved selective team of facilities management and operational (FM&O) professionals from a commercial organisation that managed around 3,400 built assets valued at £370 billion in 2003–05 in the United Kingdom. By working closely with the organisation, an approach to built-asset management was developed which integrated the existing UKCIP decision-making framework and UKCIP02 climate-change projections. In developing this approach, the strategic risk perception and managerial attitude to climate change were identified and included as important factors affecting the decision-making process.

To test the wider applicability of the decision-making framework that was developed in the participatory study, a questionnaire survey of the wider facilities management community was undertaken. It was deduced from the survey results that the intent and process of decision making remains constant amongst FM professionals in commercial settings – for example:
(a) The experience of a financial loss due to an existing climate-related extreme event is the initiation point for strategic stakeholders for considering future action regarding climate change; and (b) The operational adaptation measures are restricted to securing insurance deals and making renewed disaster-recovery and business-continuity plans. Additional outcomes from participatory and survey study covered logistic models describing the adaptation and mitigation approaches within a commercial setting.

Taken as a whole, the findings from this study show that mitigation efforts which are supported by legislation and have well defined targets achieve a strategic importance within an

organisation, while an absence of such targets and external drivers means that adaptation is viewed as an operational activity and, , as a short-term activity that has to compete for funds within annual budgets.

To raise the profile of adaptation within commercial organisations requires a shift in the perception of climate change as risks amongst FM&O professionals and ability to better recognize climate change impacts on the business and built asset functions. . This requires action to be initiated at both governmental and organisational level. However, such action needs to consider other constraints, such as the time span of the climate change projections. In particular, as FM&O professionals consider adaptation as an operational issue for which the planning period is normally short term (3–5 years), while the long-term projections associated with climate change are for 20–30 years as a minimum. In order to support decision making, this ‘temporal scale’ discrepancy needs to be addressed.

The study has demonstrated that although decision-making frameworks and projections are useful tools to the adaptation of existing commercial built assets, they need to be synchronised with the short-term business planning and operational time line. The mitigation approach due to legislative and market-performance forces is quantified and gains a strategic importance, securing substantial financial support. In contrast to this, the adaptation agenda is taken into account only in the presence of an extreme event-related financial and functional loss. In this case, adaptation to climate change remains a reactive rather than a planned process and lacks legislative drivers. In the absence of legislative impetus and a standardised quantitative assessment method, it is difficult to derive short term or long-term targets according to which maintenance management interventions can be planned and strategic support can be achieved. In addition, the perception of built-asset managers about climate change risk is also found to be affecting the adaptation and mitigation agenda for built-asset maintenance and management.

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ABI	Association of British Insurers
ARCCCN	The Adaptation and Resilience to a Changing Climate Coordination Network
ASC	Adaptation Sub Committee
BACLIAT	Business Areas Climate Assessment Tool
BCM	Business Continuity Management
BIFM	British Institute of Facilities Management
BKCC	Building Knowledge for a Changing climate
BRE	Building Research Establishment
CCC	Committee on Climate Change
CDP	Carbon Disclosure Project
CIBSE	Chartered Institution of Building Services Engineers
CIRIA	Construction Industry Research and Information Association.
CIOB	Chartered Institute of Building
CSF	Critical success factor
CSR	Corporate Social Responsibility
DCLG	Department of Communities and Local Government
DEFRA	Department for Environment, Food and Rural Affairs
Euro FM	European Facilities Management Network
FM	Facilities Management
FM & O	Facilities Management and Operation
GHG	Green House Gases
IFMA	International Facilities Management Association
LCCP	London Climate Change Partnership
LARP	Local and Regional Adaptation Partnership Board (in the UK)
NEP	New Ecological Paradigm Scale
RCCP	Regional Climate Change Partnership (in the UK)
RICS	Royal Institute of Chartered Surveyors
UKCIP	UK Climate Impacts Programme
UNFCC	United Nation Framework Convention on Climate Change
WEEE	Waste Electrical and Electronic Equipment Directive

Chapter 1 – Introduction

This chapter presents, in sections 1.1 to 1.3, a brief introduction to the research study, which considers the importance of built-asset life-cycle performance for business along with the climate change debate and its impact on business and built-asset performance. Existing approaches to mitigation and adaptation are examined and the need to integrate these into an effective long-term asset management strategy is reviewed. Section 1.4 focuses on the principal drive of this study. Finally, the research methodology and primary aims and objectives of the research are defined in section 1.5 with conclusions presented in section 1.6.

1.1 The built environment

The built environment's primary function is to mediate between the internal and external climate to provide comfortable functional space for various activities. Buildings are designed to provide the essential elements of an enclosed workspace, which affords physical security (Warren 2010). This functional space differs in different building stock – residential, infrastructural, recreational, industrial and commercial, etc. For commercial organisations, this mediation includes the ability of built assets to serve core business needs and give an optimum performance such that the built assets are not an excessive overhead or expense to the organisation.

For any built asset, there exists a building life cycle which starts at inception, continues through design and construction, on to refurbishment and maintenance and decommissioning at later stage. Amongst these the maintenance activities are undertaken at set points (depending upon a stock condition survey) throughout the operational phase of the building's life. Whilst the design and construction phase of the building life cycle has a short duration, the operational phase can last for many years and it is this phase that is more susceptible to the impacts of climate change.

The focus of this thesis is on the requirement of maintenance and refurbishment interventions to address the climate change mitigation and adaptation agenda in order to ensure that the commercial built assets continue to be viable in supporting required business needs.

1.2 Commercial built-asset performance

Built-asset performance in commercial properties is ensured through maintenance and refurbishment, which form a part of the building life cycle (Finch. E, as cited in Alexander 1998). The British Standard BS 3811: 1964 defines ‘maintenance’ as *“a combination of any actions carried out to retain an item in, or restore it to, an acceptable condition”*. (as cited in Wordsworth 2001). Although this is referred to as a standardised definition, maintenance invariably seeks restore the acceptable condition in accordance to budget constraints. In order to emphasise this aspect of improvement, the Chartered Institute of Building (CIOB) defines maintenance as work undertaken in order to keep, restore or improve every facility, to an agreed standard, determined by the balance between need and available resources (CIOB 1990). In light of these definitions, it could be argued that maintenance is critical to provide an appropriate level of performance. However, in reality most built-asset owners take the view of ‘don’t mend what isn’t broke’ because asset fabric maintenance is perceived as primarily a technical activity, which continues to be highly resource-consuming (Atkin and Brooks 2005; Barrett and Baldry 2003).

This maintenance perspective which separates maintenance interactions from the strategic consumer drivers does not help organisations to work towards buildings with improved built-asset performance in order to achieve targeted business performance fuelled by changing markets and demands. In such a scenario, what is needed is for built-asset maintenance to be aligned with the strategic goals of the organisation (Then 2000; Pitt and Hinks 2001). Such alignment is the responsibility of the facilities management (FM) function which helps the business organisation to effectively maintain their buildings (hard FM) such that they support the other core services of the business. In other words, facilities management is the process by which organisations ensures that buildings, systems and services support and achieve the strategic objectives of the organisation to changing conditions (Atkin and Brooks 2005). FM focuses on reducing risks, and its policies lay out an organisation’s response to changing environment control and protection. Barrett and Baldry (2003) further define FM as an integral approach to operating, maintaining, improving and adapting the buildings to support the primary objectives of that organisation.

Elaborating on the above definitions Finch (in Alexander 1998) identifies the role of the maintenance manager as one to work towards getting the property to its prior condition where it can fulfil its basic function in line with legislative compliance, while the facilities manager’s role is to address the constantly increasing gap in present property condition and future demands placed on it in response to constant technological advancement, user demands and market forces. This gap increases with time and other financial, legislative and climatic factors, putting additional demands on the built asset. Thus, by assessing future demands it should be possible for facilities and asset managers to devise strategies to save an existing commercial stock from reaching obsolescence.

1.3 Climate change and its impacts on buildings and business

Climate change is a significant factor that will affect how people live and work in the future. The Intergovernmental Panel on Climate Change (IPCC 2001), in its Third Assessment Report (TAR) has established that most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations and the atmospheric concentration of carbon dioxide CO_2 has increased by 31% since 1750, with the rate of increase of atmospheric CO_2 concentration being about 1.5 ppm (0.4%) per year over the past two decades (IPCC 2001). This has been reiterated by the IPCC in its Fourth Assessment Report (FAR), whereby continued greenhouse gas (GHG) emissions at or above current rates would cause further warming and include many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century (IPCC 2007a).

The IPCC has identified two pathways for responding to future climate change, namely adaptation and mitigation. Mitigation of climate change deals with a reduction in GHG in the atmosphere, while adaptation deals with taking action to reduce the impacts due to climate change and to generate benefit from the opportunities offered. The IPCC TAR (2001) defines ‘mitigation’ as *“an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases”* and ‘adaptation’ as *“an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities”*. Therefore, in the context of built-asset management, mitigation would be perceived as an intervention that reduces the future GHG emissions associated with a building whilst adaptation could be viewed as altering or changing the operational elements or characteristics of a building.

1.3.1 Climate change projections

Climate as per the IPCC is defined as average weather or statistical mean and variability of different variables such as temperature, wind speed, precipitation etc. over a period of time that can range from months to years. The classical period for averaging these weather variables to portray climate is 30 years, which is used by world meteorological organisations. Climate change is thus a change in the state of the climate, identified through changes in statistical mean and variability over the 30-year time frame or longer which are observed due to internal variability or external anthropogenic changes (IPCC 2007b glossary pg. 942,943).

'Climate change projection' is defined by the IPCC as *"a projection of response of climate system to external forcing or radiative forcing based on simulation by climate models"*. On the basis of various model runs, the IPCC FAR (2007a-AR4) presents projections which include changes to temperature rise, precipitation, sea level rise; ice cover and certain levels of regional wind patterns and weather extremes. The projections suggest that the global surface air temperature is likely to rise between 1.8°C and 6.4°C and the global average sea level is expected to rise between 0.18m and 0.59m till the year 2100. With regard to temperature extremes and cyclones, the fourth assessment report projects that *"it is very likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent"*, while storms, typhoons and hurricanes are likely to become more intense, with increased peak wind speeds and more heavy precipitation (IPCC 2007a,-AR4, SPM).

These projections are also reflected in the United Kingdom, where the UKCIP02 and UKCIP09 projections published by UKCIP (UK Climate Impacts Programme) project that over the next 50 years the UK can expect to see a rise in annual average temperature, a rise in sea levels around the UK with increased flooding of low-lying areas, higher average summer temperatures with more days reaching mid-30°C, and extreme winter rainfall with frequent storms and associated flooding.

1.3.2 Impacts on business

These future changes will impact businesses across various sectors for example, disrupted supply chains during extreme weather events, changing customer demand, and increasing business running costs and insurance costs (Frith & and Colley 2006; and Metcalf et al 2010).

IPCC AR4 2007a highlights that *"business adaptations will be in response to both direct impacts (involving direct observations of risks and opportunities) and indirect impacts (including changing regulatory pressures and consumer demand)."* Further on, citing Hertin et al. (2003) and Berkhout et al. (2004), the same (FAR) report suggests that adaptations can take a wide variety of forms and may include changes in business processes, technologies or business models, or changes in the location of activities. In the case of the United Kingdom, Markandya (2004) has outlined impacts such as increased heat stress for workers, increased cooling energy requirements, changes in patterns of demand for goods and services, increased flood risks and water supply constraints, and the impact on the insurance industry. Outlining these impacts on business, Markandya (2004) has further urged businesses to take a long-term strategic view that is both flexible and resilient enough to accommodate extreme conditions in its planning for the impacts of climate change, while Frith and Colley (2006) have drawn attention to the higher cost and longer-term business obsolescence if adaptation were not to be undertaken.

1.3.3 Impacts on built assets

The impact of climate change as outlined above on commercial organisation will in turn be felt across the business premises. This impact will be in two broad areas: first, the impact of increasing cooling energy load, legislation and carbon reduction initiatives on business energy use and its management in built assets; and, secondly, the risk to the physical state of the built assets due to flood, erosion or water penetration from driving rain, resulting in increased maintenance costs due to recurring repair work (Graves and Phillipson 2000). The following paragraphs outline both of these impacts – i.e., mitigation initiatives and the physical impacts arising from changing climatic conditions.

The impacts due to mitigation initiatives and regulations are related to the energy efficiency of buildings and their resulting carbon emissions. In the public sector the United Kingdom already has in place the Decent Home Standards 06 and Zero Carbon Buildings initiatives (till 2016), while the private sector faces legislation such as Building Regulations 2005 (Part L and energy consumption), Climate Change Agreements and Carbon Reduction Commitments 2008, which will affect the long-term viability of an organisation's built assets. This increasing legislative requirement will be difficult to meet, with increased cooling energy required in commercial buildings as a direct effect of overheating (Graves and Phillipson 2000). In addition to the impact of increasing legislation, there will also be other physical impacts felt on the built assets due to climate change, which are to date less highlighted and less researched topics. The few examples of these includes impacts across the construction industry, including refurbishment and the maintenance of domestic as well as non-domestic stock, and across the insurance industry (Graves and Phillipson 2000) .

The important impacts outlined for existing buildings centre on high-speed wind impact, which can erode buildings as they are designed using historical wind speed data, while increases in driving and heavy rain will affect the fabric, windows, cladding systems, roof and guttering of buildings. (Graves and Phillipson 2000).

Considering the above impacts due to flooding, overheating, high precipitation, change in legislation etc., the maintenance cost of properties is likely to see a sharp increase. Graves and Phillpson (2000) concludes that climate change will increase the roofing and PVC-U window maintenance cost by around £2.5 billion a year, with additional degradation of other building components.

Due to the increasing mitigation initiatives and legislation, much research is carried out in addressing CO_2 reduction from existing and newly built assets through energy efficiency for e.g. evaluating technical and policy options and GHG emission reduction through energy efficiency at national level (e.g. UK – Pout and MacKenzie 2005 and 2012; US – Brown et al 2005; New Zealand – Hargreaves 2003, WBCSD 2009). Furthermore, work by Wilkinson and Reed (2006) has particularly focused on commercial stock energy efficiency and GHG emission reduction, while Ürge-Vorsatz et al (2007) have identified the technological and retrofitting measures applicable to buildings around the world with CO_2 and cost savings.

As a result of on-going research and legislative pushes, the mitigation agenda has found an increasing strategic importance in commercial-sector built-asset management and operations as increasing targets of emission reduction are often cited within organisations' sustainability strategies or corporate responsibility strategies as an extension to energy efficiency and cost saving initiatives. As a result of this legislatively driven strategic importance given to mitigation, facilities managers receive emission reduction targets, planned and budgeted for in the overall FM strategy. These targeted reductions are realised through implementation of a mix of technical and behavioural change measures. The measures range from changing to more energy-efficient lighting and IT equipment, to training staff on relevant topics, to installing SMART meters for measuring energy outgoings and to installing green technology when successfully receiving government or other funding.

The mitigation agenda in commercial-sector built-asset thus follows a top-down approach and is set for the future business planning time period of 3 to 5 years.

In contrast to this, the loss projected as a result of the physical impacts of climate change on commercial built-asset elements is difficult to plan for in any existing FM strategic approach because no set targets or long-term risks are presently assessed or budgeted for in relation to these physical impacts at a strategic level. Thus, in the absence of any push factors the approach to address such impacts remains ad hoc and reactive, where the action is not initiated unless a functional or financial loss is registered.

Planned mitigation and reactive adaptation approaches will be less effective in the future as most of the existing office buildings will by then be either historic buildings or stock built since 1991, which are not designed to perform in the predicted future climatic conditions with regard to their energy requirements or their ability to contain the increasing physical impacts. In such a scenario the option for this commercial stock is through adapting the property through maintenance and refurbishment in order to avoid obsolescence and to serve the organisation's ongoing business needs (Jones and Desai 2006).

1.4 Formulating a new approach to built assets

In light of the literature on climate change impacts on businesses and their built assets, it is noted that both approaches – mitigation and adaptation of commercial built assets – are of equal importance to the businesses. The existing commercial built assets will have to respond to the increasing mitigation initiatives for emission reduction from building operations and also to the physical impact of changing climate and extreme events.

Since facilities managers are at the forefront of providing and maintaining the built assets to support business functions, they will need to address both mitigation and adaptation agendas in maintaining their organisation's commercial built assets in the future. In doing so, they will have to translate climate change impacts into built-asset risks.

Addressing these impacts will require a step change in thinking (in line with the renewed approach explained in Chapter 2) with regard to built-asset maintenance and management in comparison with the one prevailing at present, which uses stock condition surveys combined with strategic asset management policy and planned asset maintenance – a model that presents many gaps (Chapman 1999; Shen 1997). For fulfilling the above and supporting the facilities managers' decisions for adaptation and mitigation action, the application of an existing decision-making framework and climate change projection is suggested. This is a step change from the previous ways of decision-making framework implementation as, up till now, these frameworks has been implemented at regional or sector level, and very few examples exist for implementing them at the level of individual private-sector business built assets involving maintenance and FM professionals.

1.4.1 Research question and objectives

In light of above, the following research question was formulated: 'How can an existing risk assessment framework and climate change projection (UKCIP02) be applied to translate climate change impacts into built-asset-level risk in order to support maintenance and business-level decision making in a private-sector business?

The primary aim of the study was to develop an approach for a long-term climate-adaptive facilities management strategy, using existing tools (UKCIP uncertainty and decision-making framework in the face of climate change) and climate change projection (UKCIP02) that ensures the existing built-asset ability can continue to support the primary business functions in a cost-effective and sustainable manner.

The objectives of the study were:

(1) Identifying present FM approaches to CO_2 reduction (mitigation) and making building stock resilient (adaptation);
(2) Identifying issues related to the implementation of existing tools and climate change projections by facilities managers; and
(3) Identifying facilities managers' perception of mitigation and adaptation.

1.5 Approach taken in the thesis (methodology)

In order to achieve its aims and objectives, this research has adopted a mixed-method approach (Maxwell 2005) consisting of both qualitative and quantitative assessments (outlined in Chapter 3). The fulfilment of the first two objectives given in subsection 1.4.1 above and for implementing a decision-making framework, a qualitative approach was taken where a commercial banking organisation and its facilities management staff was chosen as the subject of a participatory study.

A small number of informal discussions and interviews, and an analysis of secondary organisational strategic documents, were carried out to assess the existing measures taken for mitigation and adaptation of climate change (Objective 1). The implementation of the framework was undertaken through participative study, where this procedure identified the assessment process adopted by FM and the emerging issues related to the implementation of the framework (Objective 2). To validate results from the singular participatory study and to fulfil the third objective of establishing FM opinion on mitigation and adaptation, a questionnaire survey was undertaken within the wider FM community. A quantitative analysis of the results obtained was used to formulate a model for an adaptation process which was found to be in accordance with past research findings and primary adaptation concepts.

1.6 Summary of conclusions

The major conclusions drawn from the research study are as follows:

(1) Mitigation and adaptation measures are treated differently within FM. Mitigation, because of legislative drivers, has found strategic importance and thus financial support. On the other hand, adaptation is considered as part of business continuity and disaster recovery planning, where the wider strategic case is not made and thus always lacks financial resources.

(2) The existing decision-making tools implementation to the built-asset maintenance and management scenario requires facilities managers to be more familiar with climate change data and projections while using quantitative risk assessment tools (e.g. Bayesian methods, Monte Carlo techniques).

(3) Facilities managers are able to carry out initial risk screening but at the same time there is a need for tools or guidelines for FM to be able to translate climate change impacts into built-asset risk and make the business case to procure additional funding. In addition, more behavioural drivers need to be introduced to stimulate adaptation action in the private sector in order to protect businesses and their built assets from obsolescence induced through the on-going impacts of climate change.

In light of these findings it is suggested that FM managers in the future will need to gain further understanding of climate change projections and develop an ability to translate projected changes into their building operation risks. In cases of existing limited understanding of the projections, an objective risk assessment using existing or adopted methods in collaboration with operational FM staff should be promoted in the commercial sector. The risks thus assessed should be translated and documented in terms of financial loss to make a strategic case.

Chapter 2: Literature review

This chapter presents the background and rationale for undertaking the research study. It formulates an overall picture of existing knowledge pertaining to different subject areas encompassed by this thesis. In doing so it also sets out the interdisciplinary nature of this work and tries to highlight interrelated issues; it looks for knowledge gaps. On this basis, research proposals are outlined and research questions identified.

In order to address the various subjects associated with this research, the literature review is divided into seven sections. Section 2.1 examines the issue of climate change as faced today the world over (including in the United Kingdom) with its relevance to the present research. The facilities' management context and the research proposal are outlined in section 2.2, while section 2.3 identifies the contextual aspects affecting facilities management (FM) action for mitigation and adaptation, namely organisations' strategic intentions, resource availability and their approach to climate change. Section 2.4 deals with the concepts of adaptation and existing research in the area where different adaptation approaches are used. An introduction to the UKCIP framework forms section 2.5. Since this research has adopted a commercial context, the associated theories are outlined for further identification of the influencing organisational factors in section 2.6. Final section 2.7 summarises the review and outlines the key knowledge gaps.

2.1 Climate change and approaches to address it

This section outlines the issue of climate change as faced today. It specifies the projections made in accordance to climate change models, changes observed until now and the two approaches suggested for dealing with climate change, namely mitigation and adaptation. In light of this, the UK approach to mitigation and adaptation is identified specifically in the context of commercial built assets. This background is used to explain the rationale for the present research.

2.1.1 Climate change

The overall warming of our climate is attributed to the increase in greenhouse gases (GHGs) – e.g. methane, carbon dioxide, ozone, sulphur hexafluoride, hydrofluorocarbons and perfluorocarbons – arising from the industrial development of the past 250 years. The Intergovernmental Panel on Climate Change (IPCC), in its Fourth Assessment Report (FAR;

IPCC 2007a), has established that *"most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations"* (IPCC 2007a, p5) and *"Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004 and annual emissions of CO_2 grew by about 80% between 1970 and 2004"* (IPCC 2007a, p5).

Successive IPCC assessments have furthered the understanding of anthropogenic warming and the IPCC 2007 FAR concludes that there is now improved understanding leading to 90% confidence that the global average net effect of human activities since 1750 has been one of warming, with an observed total temperature increase from the 1850–99 period being 0.76°C (range: 0.57°C to 0.95°C) up to 2001–05.

The increase in emissions is governed by the dynamics of factors such as population, socio-economics and technical improvements, all of which are not completely understood. A In order to address these fragmented aspects the scientific community has adopted a scenario building approach and has formulated various scenarios for addressing future development. Nakicenovic et al in IPCC (2000) presents four families of such scenarios, each dependent upon developments described in terms of different social, economic, technological, and environmental and policy aspects. Among the many scenarios available, three have been chosen to present low, high and medium emission levels (refer to IPCC 2007b p753 for a detailed explanation). These in turn are used to drive climate simulations for the period up to the year 2100.

2.1.2 Climate change projections and observed impacts

In accordance with the climate change simulation model given in IPCC 2007a and 2007b, the projection includes changes to temperature rise, precipitation, sea level rise and reduction in ice cover, together with certain levels of regional wind patterns and weather extremes.

The projections suggest the global surface air temperature is likely to rise between 1.8°C and 6.4°C. The global average sea level is expected to rise between 0.18m to 0.59m, which (in the high emission scenario) can possibly increase by 0.1–0.2m due to ice sheet shrinkage in Greenland and Antarctica. Snow cover is predicted to be contracting with sea ice shrinkage in both the Arctic and Antarctic under all emission scenarios (IPCC 2007a).

According to the expert judgement from the projections about precipitation there is a 90% probability of an expected increase in precipitation in high-latitude areas. With regard to temperature extremes and cyclones, the Fourth Assessment Report projects that *"it is very likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent"*, while storms, typhoons and hurricanes are likely to become more intense, with increased peak wind speeds and more heavy precipitation (IPCC 2007a, p15).

The impacts of already occurring climate change are visible on many physical, biological and human systems. These changes are observed by IPCC Working Group II in the FAR as *"enlargement and increased numbers of glacial lakes, increased runoff and earlier spring peak discharge in many glacier- and snow-fed rivers, and range changes and earlier migrations of fish in rivers"* as well as earlier timing of spring events such as leaf unfolding, bird migration, bird egg laying, and a pole-ward and upward shift in the ranges in which plant and animal species are found (IPCC 2007a, pg. 8).

2.1.3 Responses to climate change

The scientific community has noted the observed and predicted impacts of climate change on human systems (IPCC 2007a). These impacts comprise flooding, drought and adverse effects on human health, food security (due to the impact on fisheries and agriculture), and human settlements near coastal and low-lying areas around the world (due to sea level rise) and energy demands (for cooling). The recently produced IPCC SREX (2012) report has highlighted that there is a medium confidence that impacts of events such as heat waves have been found to be increasing over the 20^{th} century for central Europe and are projected to be increasing in the future, while there is low confidence that events such as hurricanes in the United States and the Caribbean resulting in economic losses have increased and it is likely that the frequency of such events may remain unchanged (IPCC 2012).

The UK projections outlined in the UKCIP02 and UKCP09 modelling results are consistent with observed global-level changes. Central England temperatures were found to have risen by 1ºC through the 20^{th} century, while winters across the UK have been getting wetter, with major precipitation falling in the heaviest downpours, and summers getting drier. The sea level rise across the UK coastline has been 1mm per year in the last century (Hulme et al 2002).

The projected changes noted in UKCIP02 for temperature, precipitation and sea level rise indicates a rise in UK annual average temperature between 2°C and 3.5°C by 2080, with the South East of the UK becoming warmer than the North West in the summer and autumn. A decrease in UK precipitation of 0–15 % by 2080 is also predicted, with substantial regional and seasonal differences, and a decrease in snowfall by 30–90% by 2080 (Hulme et al 2002). As Hulme et al state in the same report (page v*): "extremes in the weather will be experienced as the average temperature of 3.4°C above normal may occur as a one in 5-year event by 2050 considering the medium-high emissions scenario"* and they further note *"extreme winter precipitation becoming more frequent by 2080 and with 20% heavier rainfall experienced every 2 years on average"* while the *"UK sea level may be between 26 and 86cm above current level in southeast, causing increased risk of flooding in the area"*.

The record-breaking temperatures of 38.5° C at Brogdale near Faversham (Kent) in August 2003 (see www.metoffice.gov.uk/climate/uk/extremes), extreme rainfall (200mm in 24 hours) around Boscastle in August 2004 causing large-scale flooding (see http://news.bbc.co.uk/go/pr/fr/-/1/hi/england/cornwall/3571844.stm) and recent floods in the United Kingdom during the summers of 2007 and 2009 resulting in economic and social damage (see http://news.bbc.co.uk/go/pr/fr/-/1/hi/uk/6971370.stm) are examples of the likely impacts of climate change on human systems and indicate that alignment with projected climate change is already occurring.

The impacts of future climate change on agriculture, buildings, health, forestry, biodiversity, transport, planning, finance and other sectors would be widespread and negative in nature. Reduced yields in the absence of irrigation, increased drought and flood damage, increased urban flood and overwhelmed drainage systems, subsidence danger and cooling energy demands in summer are some of the impacts already identified (West and Gawith 2005).

2.1.4 Approaches to climate change mitigation and adaptation in the UK

The two pathways for responding to climate change are adaptation and mitigation. Mitigation of climate change deals with reduction in Green House Gases (GHGs) in the atmosphere while adaptation deals with taking action to reduce the impacts from climate change and generating benefit from the opportunities offered. The IPCC Third Assessment Report (IPCC 2001, pgs.

365, 379) defines ‘adaptation’ as *“adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities”* and ‘mitigation’ *as “an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases”*.

The initiatives and mechanism for mitigation is well established through the United Nations Framework Convention on Climate Change (UNFCC) and the associated Kyoto Protocol, which sets binding targets for CO_2 emissions for the parties to the Convention (i.e. the contributing governments). As per the Kyoto Protocol, an average 5% reduction in the amount of emissions was to be achieved by the participating countries (37 industrialised countries and the European Union) through the years 2008 to 2012, compared with the baseline level of 1990, using policy measures and mechanisms offered by the Protocol, namely emissions trading, the clean development mechanism (CDM) and joint implementation (see http://unfccc.int/kyoto_protocol/items/2830.php).

Many of the countries have fulfilled their targets and have now set renewed targets for further reductions, but the collective agreement on these efforts remains low in present times. The recent convention of the parties to the UNFCC established the Durban Agreement in 2011, where the parties to the convention (the developed countries) agreed to adopt a universal legal agreement in CO_2 reduction. As per the UK’s Department of Energy and Climate Change (DECC), the Durban Agreement has been successful in:

- Achieving a global agreement on a roadmap to a legally binding deal;
- Agreement for a second commitment period of the Kyoto Protocol to be agreed in 2012; and
- Consensus in setting up a ‘green’ climate fund.

These targets are set to be decided upon in Bonn. Germany, in May 2012.

In light of this international progress the EU has agreed on a 20% reduction for 2020 levels relative to 1990 levels, while the UK has set the new target as 80% reduction in emissions by 2050 in comparison with 1990 levels through the Climate Change Act 2008 (DECC 2009, 2011).

In order to deliver on the committed emission targets, the UK Government has promoted policy, regulation and awareness measures outlined in its Climate Change Programmes 2000 and 2006 and in DECC (2009) for energy supply, business, transport, domestic, agriculture, forestry, land use management and the public sector. The measures presently implemented include renewable Obligations, climate change levy, the emissions trading scheme, the Carbon Trust initiatives, the Building Regulations 2005, climate change agreements, energy efficiency commitments and recently designed carbon reduction commitments (DECC 2009). In addition to the foregoing the newly formulated Climate Change Act 2008 implies a regular accountability to the UK Parliament and devolved legislatures for action on climate change mitigation and adaptation.

In the United Kingdom, attempts for adaptation are included in the Climate Change Programmes of 2000 and 2006, yielding an adaptation policy framework. In recent years, under the Climate Change Act 2008 and the Committee on Climate Change, an Adaptation Subcommittee has been formed. This subcommittee has identified five priority areas for preparing a national adaptation programme, namely:

- Land use planning;
- National infrastructure;
- Designing and renovating buildings;
- Managing natural resources; and
- Effective emergency planning.

In addition, the subcommittee has identified three major components, namely outcomes, action and decision making, for measuring the progress made in each sector. It has reported on progress in ASC (2010); ASC (2011 on adaptation in the above sectors. The DEFRA (2012) report provides additional evidence for climate change risk assessment in the United Kingdom.

In 1997, i.e. prior to establishment of the Climate Change Act 2008 and the Adaptation Subcommittee, UKCIP had the sole intention of providing essential information to stakeholders for planning for a changing climate. The programme has subsequently successfully undertaken numerous research activities in different sectors for formulating adaptation tools, such as the UKCIP Business Areas Climate Impacts Assessment Tool (BACLIAT) and its risk, uncertainty and decision-making framework (Willows and Connell 2003) which has been recognised by the

UNFCC compendium for methods and tools to evaluate the impacts of, and vulnerability and adaptation to, climate change.

Although UKCIP has been actively involved in progress towards adaptation, Demeritt and Langdon (2004) suggest that the communication of UKCIP to local authorities in the UK and its role in conjunction with DEFRA remains ambiguous and needs alteration in getting the adaptation communication and information through for use by public and private sector alike. From 2011, DEFRA transferred the responsibility of climate change adaptation delivery from UKCIP to the Environment Agency with a £2 million annual budget (DEFRA 2011).

Although the UK Government has been proactive on the adaptation and mitigation fronts, many adaptation and mitigation measures and policy instruments have been developed separately when they need to be complementary in their nature. This is reflected in the commercial setting, where mitigation is already being addressed by many businesses but adaptation measures and decisions still have to find firm grounds in organisations' future planning (Firth and Colley 2006). Since the emergence of the Climate Change Act 2008, the Committee on Climate Change (CCC) and its Adaptation Subcommittee have worked in collaboration to assess future climate change impacts in terms of achieving the UK emission targets and to adapt to the future impacts of climate change. This work is reflected in successive carbon budget reports and the measuring of progress towards adaptation (CCC 2010; ASC 2011).

The IPCC (2007b, p748) has also emphasised this point, by stating that *"it is no longer a question of whether to mitigate climate change or to adapt to it. Both adaptation and mitigation are now essential in reducing the expected impacts of climate change on humans and their environment."*

2.1.5 Significance for this research and rationale for adaptation for commercial built assets

In light of the literature on approaches to mitigation and adaptation of climate change, it is noted that both these approaches are of equal importance to businesses and their existing and future built assets, since existing commercial built assets will have to respond to the increasing mitigation initiatives for emission reductions from building operations and also to the physical impact of a changing climate and extreme events.

This is emphasised by Camilleri et al (2001), Camilleri and Jaques (2001), Liso (2001), Liso et al (2003) and Salagnac (2007), each of whom have noted the impacts of climate changes specifically in the building industry which have risen as a result of recurring extreme-event damage repairs and insurance costs, carbon taxation, expenses for replacing less-efficient equipment with more energy efficient ones, and increased outgoings due to higher energy bills. They further suggests that addressing these issues would require policy formation for reducing GHG emissions from buildings and also preparing them for future climate changes through site-specific and regional impact research. The failure to address the above would possibly render the existing property portfolios obsolete as they would no longer be able to serve their organisation's business needs (Jones and Desai 2006).

2.2 The facilities management context: present practices and the research proposal

In order to address climate change mitigation and adaptation approaches for existing commercial built assets, it is necessary to understand the present maintenance and facilities management practices. This section presents current maintenance models and facilities management practices. In doing so it points towards the gap which requires to be addressed in order to accommodate present and future climate-change mitigation and adaptation options. It does so by outlining the research proposal and its aims and objectives.

2.2.1 Need for facilities management

Today's businesses are not restricted by geographic boundaries and their corporate identity cannot be fully defined by only core activities. The maintenance and management of the non-core services – which includes their built-asset portfolio, is also a high priority and ignoring this could affect an organisation's overall corporate image and result in financial loss through obsolescence of the built-asset portfolio.

FM helps a business organisation to effectively maintain its buildings such that they enhance the non-core services in support of the primary business objectives. In other words, facilities management is a process by which an organisation ensures that buildings, systems and services support and achieve their strategic objectives in changing conditions. FM focuses on reducing risks, and its policy lays out an organisation's response to vital issues such as space allocation and changing environment control and protection (Alexander 1998).

In today's scenario of increased environmental legislation – especially with regard to climate change mitigation and energy efficiency – there are increasing demands placed on built assets for reducing emissions in accordance with maintaining the required service delivery standards. This demand will also be coupled with the need for making the built assets habitable and resilient to the extreme events and future climate changes as projected by climate change science, which will need to be responded to by the maintenance and facilities management personnel within all commercial organisations.

2.2.2 Existing maintenance models and related issues

Maintenance routines in facilities management are required in order to keep property functioning to a required standard and to serve the organisation's business objectives. British Standard BS 3811:1993 defines maintenance as *"a combination of any actions carried out to retain an item in, or restore it to, an acceptable condition"*. The actions here are those of initiation, organisation and implementation. Maintenance also seeks an improved performance compared with what previously existed at reasonable budget level. In order to emphasise this aspect of improvement and budget, the Chartered Institute of Building (1990) defines maintenance as *"work undertaken in order to keep, restore or improve every facility, i.e. every part of the building, its services and surrounds, to an agreed standard and legislation determined by the balance between need and available resources"*.

In light of these definitions it could be said that maintenance is important in order to achieve the necessary standards of performance, yet in reality such maintenance continues to be a highly resource-consuming activity (Alexander 1998; Barrett and Baldry 2003). In accordance with these perspectives, the present maintenance models exist in two major prevailing maintenance approaches, namely as planned preventive maintenance and as reactive (corrective) maintenance. BS 3811 defines 'planned maintenance' as *"maintenance organised and carried out with forethought, control and the use of records to a predetermined plan"* and 'preventive maintenance' as *"maintenance carried out at predetermined intervals or other prescribed criteria and intended to reduce the likelihood of an item not meeting acceptable conditions"*. Thus preventive maintenance which is normally planned is defined as 'planned preventive maintenance' (Wordsworth 2001). Planned preventive maintenance is divided into schedule-based and condition-based maintenance, as shown in Figure 1.

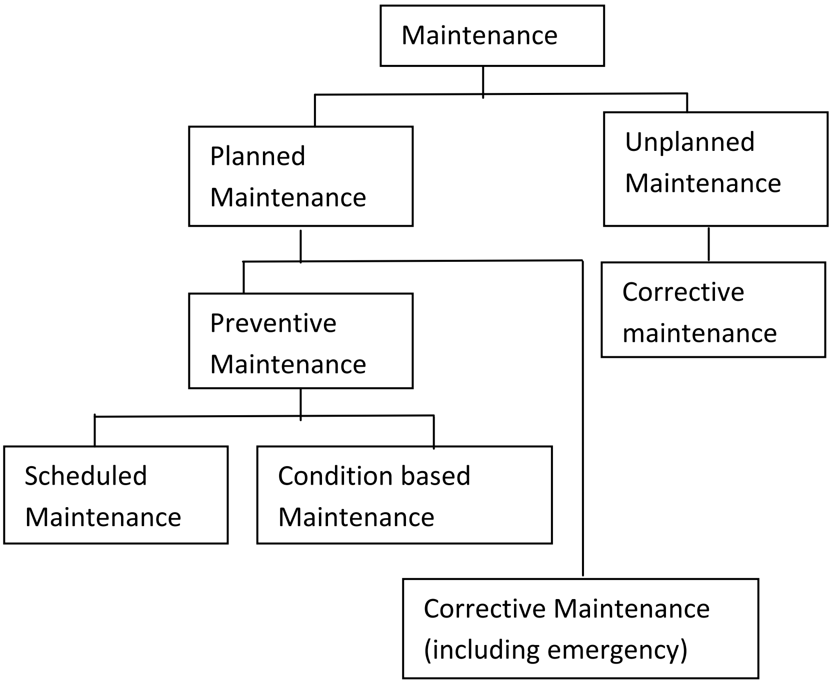


Figure 1: Types of maintenance (Source: Chanter and Swallow 2007)

The present practices and decision-making processes of planned preventive maintenance are largely based on a stock condition survey. There are a number of issues associated with the stock condition survey approach, which informs the basis of the present research proposal.

2.2.3 Issues with current maintenance approaches

As mentioned in the preceding subsection, the existing planned preventive maintenance approach in facilities management is derived from a stock condition survey and a decision-making process where the condition survey is combined with organisational needs and budgetary requirements. The alternative long-term maintenance strategies are then assessed for deciding on short-term targets. The issues in this current approach with using a stock condition survey and a certain lack of objectivity with prioritising maintenance activity are emphasised by both Chapman (1999) and Shen (1997). The other gaps in this approach – both in the public and the private sector, especially with regard to addressing wider parameters (sustainability or climate change) – have been highlighted by Jones (2002), Jones and Sharp (2007) and Cooper and Jones (2008).

In the private sector an organisation's long-term business plan and corporate strategy are rarely well defined and are not predicted more than three to five years into the future. This restricts the inclusion of an organisation's demands for its present maintenance approach (Jones and Desai 2006; and Jones and Sharp 2007). The present-day issues of sustainability and climate change also play a part in placing an additional demand on the business needs, which the present maintenance model will not be able to support with use of the current approach mentioned above. This will lead to properties being obsolete with future changes. This is explained with the help of a framework put forward by Jones and Desai (2006), adapted from Finch as cited in Alexander (1998).

Highlighting the role of facilities managers, the framework proposes that while maintenance managers update a property to a predefined level till the time of the next refurbishment activity, the facilities managers should ensure the property remains at least at the required standard in order to keep up with the technical and organisational demands which are already on the increment path from the time the building came into the portfolio. Thus property and facilities managers are always playing catch-up with the existing and required standards of the property (Figure 2). When demands due to the sustainability and climate change agenda are added to the portfolio, then the already constrained finance and maintenance planning could well render all or part of the portfolio obsolete (Figure 3).

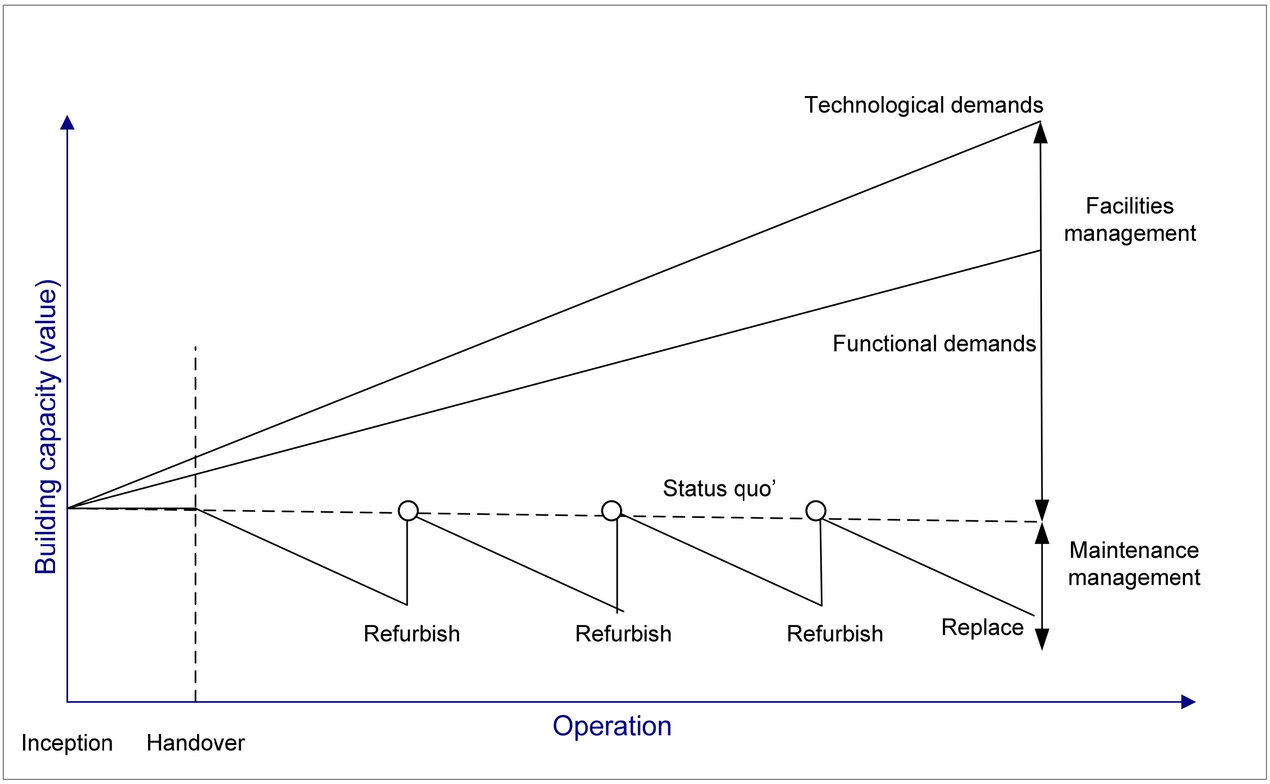


Figure 2: Maintenance and refurbishment cycles – 1 (adapted from Finch as cited in Alexander 1998)

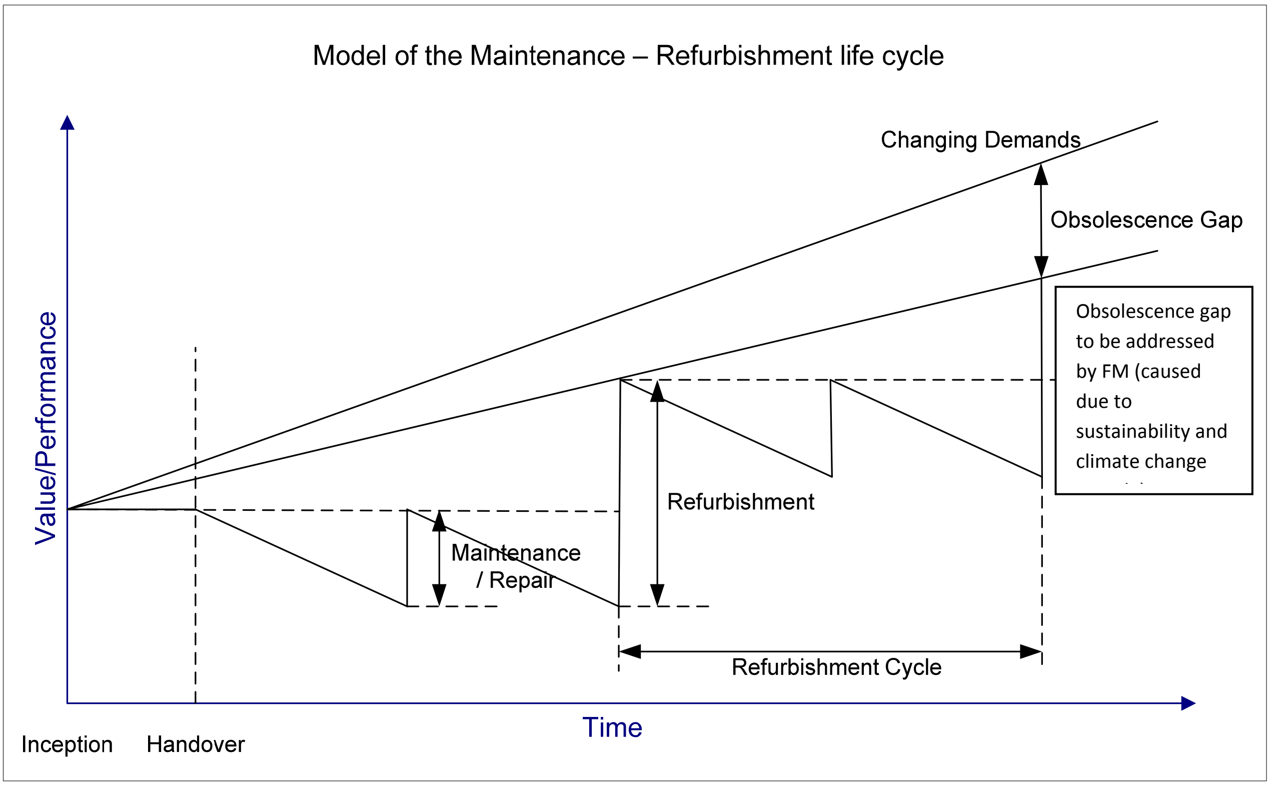


Figure 3: Maintenance and refurbishment cycles – 2 (adapted from Finch as cited in Alexander 1998)

Recognising these newly imposed needs from an existing built-asset portfolio has led to a renewed approach to maintenance and facilities management being suggested by Jones (2005), and this is adopted for the purpose of the present research.

2.2.4 Basis for the research proposal

Jones (2005) suggests that since climate change will affect most of the existing buildings in the United Kingdom, if organisations and facilities managers could project their building demands imposed due to climate change (the refurbishment cycle for existing buildings) forward for the next 25 years then, with a clearer view as to their long-term needs, it would be possible to develop a maintenance-and-refurbishment strategy by looking back. This will inform the changes that will be required for the building's operation, which are different from today, and thereby enable properties to be adapted to long-term changes over 20–30 years instead of being rendered obsolete.

In this scenario, maintenance and refurbishment actions are planned because they are integral to achieving long-term building performance goals in the face of climate change rather than as ad-hoc responses to short-term problems and dysfunction caused by climatic changes. Furthermore, because this approach would integrate maintenance-and-refurbishment planning into an overall asset management strategy, it should improve the confidence of building owners in the ability of their built assets to perform in changing climatic conditions over the long term, ultimately proving more cost-effective.

Taking as a basis the above theoretical model, it should be possible for facilities managers to construct a climate change adaptive strategy (for a 20–25-year time frame) for their properties by assessing the projected impacts of climate change and its effect on buildings.

In order to realise the aforementioned conceptual framework, UKCIP02 data for 2020 (i.e. the next 30-year time frame, from 2011 to 2030) was intended to be used in the present study for assessing the impacts of climate change on existing built assets. These projections and assessments were intended to be used in conjunction with the UKCIP risk, uncertainty and decision-making framework (described in detail in section 2.5) using a participatory study approach.

The participatory study included a sample of a built-asset portfolio and a small team of facilities and operational managers with whom the UKCIP risk and uncertainty framework was applied (details of the chosen organisation and the implementation of the UKCIP framework can be found in Chapters 4 and 5 respectively).

The primary aim of the study was to develop an approach for a long-term climate-adaptive facilities management strategy, using existing tools (e.g. the UKCIP uncertainty and decision-making framework in the face of climate change) and climate change projections (UKCIP02), which ensures the ability of existing built assets to support the primary business functions in a cost-effective and sustainable manner. This aim was realised through following the research question and objectives.

The research question for the study was formulated as ‘How can an existing risk assessment framework and climate change projection (UKCIP02) be applied to translate climate change impacts into built-asset-level risk in order to support maintenance and business-level decision making in a private-sector business?’ and the three primary objectives were:

- Identifying the present FM approaches to CO_2 reduction (mitigation) and making building stock resilient (adaptation);
- Identifying issues related to the implementation of existing tools and climate change projections by facilities managers; and
- Identifying facilities managers’ opinions on mitigation and adaptation.

As a result of achieving the aforementioned objectives and answering the research question, the study would be able to establish an assessment process developed by the team of facilities managers from the participating organisation and an adaptation process which would be observed through the participatory study and subsequent questionnaire survey (see Chapters 6 and 7). In addition, the contextual factors for businesses and FM to adapt to and mitigate against climate change would also be established. The future direction in terms of UK Government drive, knowledge awareness and suggested ways for driving adaptation could then be set out (see Chapter 9).

2.2.5 Climate change impacts on buildings

Although the climate change projections for the United Kingdom have been described in great detail by Hulme et al (2002) for UKCIP02, and more recently UKCP09 has been constructed, there exists very little literature on their impacts on built assets. (This also points at the need for research on the topic.) However, Graves and Phillipson (2000) notes the impacts will be felt in the construction, refurbishment and maintenance of domestic as well as non-domestic stock, in the building regulations, and in the construction and insurance industries.

The important impacts outlined by Graves and Phillipson (2000) for existing buildings are impacts due to high-speed wind – which can erode many existing buildings, driving rain affecting the fabric of the building, leading to greater weathering action than experienced at present and the impact that mitigation legislation will have on the energy use of commercial buildings, which will in future require more cooling energy as a direct effect of overheating from increased ambient temperatures. In addition, overheating will also result in failure of critical IT systems (e.g. air traffic control, computers, fire detection systems, lift controllers), compromising both safety and commercial profitability

.

Among all the impacts mentioned due to climate change, the loss due to flooding is the greatest.. The damage to the building fabric and the effects on services result in high insurance claims in mainland Europe and the United Kingdom, as Europe accounted for US$16 billion of damage for the floods which occurred in 2002, and during the 1998–2003 period the claims for storm and flood damage in the UK doubled compared with the previous five years (see www.abi.org.uk). As per the ABI anniversary report in October 2005, in spite of the UK Government's increased spending of £570 million per year by 2005 and a further commitment of the same spend till 2008, at least 180,000 homes and 60,000 business premises in England and Wales were still deemed to be at significant risk of flooding in 2008. These figures continue to rise since then..

Considering these impacts due to flooding, overheating, high precipitation, as well as changes in legislation, the maintenance cost of properties would see a sharp increase. Graves and Phillipson (2000) conclude that climate change will increase roofing and PVC-U window maintenance costs in the UK by around £2.5 billion a year, without counting the degradation of other building components.

2.2.6 Existing private-sector built-asset stocks within the UK

In the UK, the total floor space of commercial and industrial stock in 2008 was 596 million square metres, with an average national cost per square metre of £65 and London commercial and industrial premises costing almost double that at £128/m² (DCLG 2009). DCLG statistics for 2004 on the age of commercial properties states that almost 50% of stock was built before 1940; another 40% dates from 1940 to 1990; and only 9% was added between 1991 and 2003 (DCLG 2005). This implies that very little is added to the commercial stock in the UK and most of the commercial assets present today will be there with us in coming 50 years. This stock will need maintenance and refurbishment measure to address legislative CO_2 targets. .

A considerable amount of research has been undertaken on the sustainability and energy efficiency of the aforementioned commercial stock in order to fulfil the set mitigation targets through technical and policy drivers (ACE 2003; Carbon Trust 2009). In addition to technical measures Wilkinson and Reed (2006) highlights the role of perceptions of building owners and managers play in reducing targeted CO_2 and addressing sustainability issues through refurbishment. , as It is argued that the economic argument for any improvement in commercial stock takes precedence over any other factors. This is asserted in the RICS report by Cook (1997), which mentions the rare importance given to thermal improvements in commercial properties and the low incentives for landlords due to passing all running costs on to occupiers.

Focusing on the economic argument, the DCLG (2000) property advisory group's annual report sets out concerns regarding the higher priority given to value for money over ethical issues in addressing sustainability of commercial stock – stock that is only altered after external pressures from customers, environmental audits and the existing *"mismatches between the delivery of sustainable development and the enjoyment of its benefits"*.

The climate change agenda has historically given more precedence to mitigation and energy efficiency in the building sector, with very little work undertaken to adapting/increasing resilience of the present commercial stock to future climate. The need for such work could be emphasised by the loss suffered by businesses as a result of the flooding which occurred in 2006, which was £401 million, while in 2007 the insurance industry paid out on 35,000 commercial claims (ABI 2007; Environment Agency 2008). Drawing on the issue of property damage and insurance cost, Milne (2004) has stated that as extreme weather events increase in the future due to climate change, so more savings income could be diverted towards the high maintenance and repair cost of buildings, and a property portfolio could become less attractive, resulting in insurers adopting a safety net approach leaving household and commercial property owners to absorb significant parts of the risk. In spite of these findings, the 2006 survey of SMEs by insurance company AXA (Crichton 2006) reported that 76% of businesses interviewed did not think of flood or fire as a major risk and 89% were of an opinion that they were covered by insurance for such risks. In order to be resilient to future climate change, it is clear that businesses will need to adapt their properties.

In spite of the urgent need to make the commercial built-asset stock and businesses resilient to future climate change, very little research has been carried out in the area of commercial property adaptation. This is been confirmed in the study carried out by Kenny et al (2006), suggesting that so far the literature into the physical impacts of flood on the fabric of buildings has been concentrated on the housing sector and nothing specifically has been mentioned relating to commercial sites and buildings.

The studies carried out on the topic of adaptation to future climate changes point towards aspects of regional-level hazard assessment, suggestions for risk assessment, flood risk assessment and technical fixes and repairs (Sherbinin et al 2007; Huq et al 2007; Garvin et al 2005 for CIRIA; McBain et al 2010 for CIRIA). It could be concluded that the buildings and infrastructure can offer the highest opportunity to adapt to the increasing number and magnitude of flood events (Stern 2006). But as mentioned before, there exists a gap in present-day research of studies undertaken for addressing the issues of adaptation in commercial-sector building stock. By addressing this wider gap, this current research suggests a new approach in the management of properties by taking a long-term view of maintenance and facilities management strategies.

2.2.7 The existing research gap

The ever-increasing research in the topic of the built environment and climate change currently focuses on evaluating technical and policy options for GHG emission reduction through energy efficiency at a national level (e.g. UK – BRE 2005; US – Brown et al 2005; New Zealand – Branz 2003 , WBCSD 2009). In particular, the Australian cases examined by Wilkinson and Reed (2006) emphasise energy efficiency and GHG emission reduction with regard to commercial stock. The measures for emissions reductions include using energy-efficient appliances, facade retrofitting, insulation, mandatory carbon labelling schemes and energy from renewable sources. Amongst these, the case for technological and retrofitting measures applicable to buildings around the world with CO_2 and cost savings is documented by Ürge-Vorsatz et al (2007). In the UK much of the research till now has concentrated in making the housing stock sustainable. This is evident in standards such as the Decent Homes and Sustainable Homes standards by the DCLG and in extensive research by Boardman (2007), Lowe and Oreszczyn (2008) and Reeves et al (2009), while the sustainability and emission reductions from existing built-asset stock through maintenance has been addressed by Cooper and Jones (2009).

The non-domestic stock in the UK has been addressed through legislation and initiatives taken by the Carbon Trust, BRE and the Energy Saving Trust. The DCLG (2007) report on carbon reduction from new non-domestic buildings, the policy consultation (DCLG 2010) on zero-carbon new non-domestic buildings and the CRC scheme launched in Aug 2010 are recent additions from UK Government.

In spite of such extensive research on the issue, some limitations to emission reductions from commercial built-asset stocks remain. There is also the a need to consider new technical solutions and construction methods, fragmentation of the construction industry, the linear design process, cost-based competitive tendering, organisational and institutional inertia, poor quality information and professional conservatism.(Liso et al. 2007; Scrase 2001 and Sorrell 2003).
Compared with mitigation-oriented research, the research on adaptation has not been as prominent over the years. The comments highlighted on adaptation deal with new build, where Steemers (2003) argues for the adaptation of new builds through design and occupant behaviour, while adaptation to overheating is highlighted by Hacker et al (2005), Coley and Kershaw (2010) and Levermore et al (2004). An overarching risk-assessment approach for adapting the infrastructure and built environment to the changing climate effects in Victoria, Australia is outlined by the CSIRO project (Jones and McInnes 2007) whilst a rating methodology derived from a simulation scenario where flooding, overheating and other climate change effects for housing and office blocks has been derived by Jacques et al (2000).

A few research topics have been suggested for the adaptation of existing building stock where technical measures for adaptation to flooding and the need to find synergies between policies and the regulatory framework at the national and local level are emphasised by Liso et al (2007).. A long-term approach to built-environment adaptation through the study of its past behaviour and understanding the interrelationship between the behaviour of built assets and the organisation using it, is promoted by Kohler and Yang (2007) who along with White (2004) highlight the limitation as an existing gap in dealing with monitoring, projections, and addressing uncertainty along with institutional and behavioural aspects.

The current research initiatives within the UK, reviewed by Lowe (2001) emphasise the increasing research undertaken by the insurance and academic sectors on risk assessment, technical adaptation options, and argues the need for locally viable demonstrated technologies, comprehensive building regulations integrated with local and regional policies and need for reliable regional climate projections, necessary to plan for future actions.

The aforementioned research places its emphasis on future mitigation targets and adaptation of the built environment for new stock. The strategies and measures to deal with the existing stock of properties has comparatively achieved less attention. In particular, the role that maintenance and facilities management can play in achieving CO_2 reduction and preparing the stock for impacts such as flooding and overheating are less well understood and discussed. The recent contribution by Warren (2010) in this area highlights the lack of integrating increasing extreme events and climate change in disaster risk recovery planning within organisations, but once again an attempt to find a solution taking a long-term view of an organisation's FM and maintenance practices to address climate change impact remains absent.

2.3 Contextual aspects affecting FM action for climate change

Historically, facilities management has taken a major role in the maintenance and management of an organisation's built assets. In the recent past sustainability, corporate social responsibility (CSR) and the environmental agenda have together made a strong case for FM importance in achieving an efficient bottom line, staff well-being and a good corporate image. The present focus on mitigation, and mitigation practices are incorporated within the sustainability agenda and have given rise to many performance-based engineering and maintenance standards (Price and Putnam for the Northwest Energy Efficiency Council- http://www.putnamprice.com/pdf/IFMA_Paper_Final.pdf).

In a present scenario of legislatively implied energy efficiency and mitigation initiatives, facilities managers are regarded as front runners in delivering built assets that support business need fulfilling the required legislation standards and producing effective bottom-line savings.

While delivering sustainability within a climate change agenda, facilities managers are faced with many barriers. In These are highlighted in the existing literature as time constraints, lack of knowledge and lack of senior management commitment (Elmualim et al. 2010). In light of this, the remainder of this section discusses environmental aspects at the operation and maintenance level, finance and resource availability, an organisation's approach to the 'green' and climate change agenda, and existing perceptions about climate change.

2.3.1 FM in the context of an organisation's strategy, structure and culture

Facilities managers are associated with two major activities in any organisation: providing appropriate functional building space, and maintaining and managing the built assets (Then 2000). The built space required by every business will differ in nature as will its maintenance, management and FM practices which in turn is affected by differing strategic, cultural and environmental contexts.

Much of an organisation's strategy is derived from the sector and marketplace it operates in e.g an organisation's strategy in the food and beverages sector will differ from that of one in the IT sector. Giving an example from the banking sector, Krumm (1998) mentions that in present times there are different demand placed on banking built assets and their management, and that the difference in working practice, organisational structure and strategy will influence the future trends in facilities management of banking sector.

In addition to being influenced by an organisation's strategic and structural aspects, it has been suggested that cost saving has been the prime strategy for operational effectiveness and that FM budgets are modest compared with an overall company budget, but yet account for almost 90 % of the cost sheet. Owing to this, FM actions are largely cost-constrained and thus tend to fulfil the minimum required standards set by the organisation, instead of best practice. (Krumm 1998, and Junnila 2004 citing Leibowitz 2001). Dwelling on interconnections between strategic goals and facilities management four levels of relationship are defined by Jensen (2008) based on Barrett and Baldry (2003):

- Fully integrated strategic FM;
- Proactive strategic FM;
- Reactive strategic FM; and
- Passive non-strategic FM.

However, much of FM practice presently lies in the domain of reactive and passive strategic FM (Alexander 1998). In order to achieve the best value, FM practices, are required to be aligned to the organisational goals. In order to achieve this, alignment between organisational structure, work processes and physical environment must exist. For rendering proactive facilities, Then (1999) suggests a clearly defined intent for facilities management in strategic output, a clear strategic direction from senior management and specific measurable results from operational management.

The barriers to this alignment of strategic intent and FM practices, defined by Then (1999) and Pitt and Hinks (2001), include a lack of clear communication links between the horizontal and vertical hierarchy and overall structure of the organisation. By identifying minimal input and feedback from facilities and property managers to board-level decision making and thus the strategic agenda, Pitt and Hinks (2001) assert *"that existing organisational structures tends to repress the need for integration of the functional and strategic dimensions of FM, through physically separating responsibility and that these organisational structures should be constructed in an enabling rather than a disabling form"*.

In recent years, even though sustainability and climate change mitigation have found a strategic importance (at CSR level), progress on their integration remains hindered by non-participation of facilities managers at the strategic decision-making level and by a lack of clear communications on specific measurable results. Elaborating on these, the BRE (2006) highlighted time constraints, lack of understanding of the business case, lack of information and training, and non-affordability as key impediments to delivering CSR across an organisation.

Since the performance of the built asset is high on any organisation's agenda, in order to promote the sustainability agenda, the concept of integrating environmental performance along with the already existing agenda of cost, finance, quality, time and service has been suggested by Jimenez and Lorente (2001). They along with Jullina (2004) argue that since operational functions are responsible for much of CO_2 emissions, environmental performance should be included in operational management of the organisation on the basis that it will provide benefits of a social fit for the organisation and a competitive advantage.

In order to promote environmental performance and address the recent climate change agenda under a wider umbrella of the sustainability argument,, organisations construct various scenarios of operational and strategic options. This in turn shapes their overall approach towards climate change and is important as a factor for deciding FM action for climate change mitigation and adaptation.

2.3.2 Approach to sustainability and climate change

The sustainability agenda has been affecting the commercial sector since the emergence of the Brundtland report in 1987; This in turn gave rise to the World Business Council for Sustainable Development (WBCSD) in 1995 and sustainability indices such as that maintained by the Dow Jones. The communication of the human, environmental, social and economic impacts of climate change on businesses and their reduction measures has led to a program of corporate environmental and social responsibility (also known as corporate social responsibility (CSR).

The formulation of a CSR policy, an environmental policy and environment impact management have become of prime importance to the businesses and industry which in the beginning took on voluntary reporting () in order to manage their corporate image with their customers and stakeholders, gain competitive advantage and abide by ever-increasing legislation (Arora and Cason 1996; Hussein 1999, Sharma and Vredenburg 1998, and Stoeckl 2004,;). Thus for any company, giving a high priority to CSR is no longer seen to represent an unproductive cost or resource burden but, increasingly, a means of enhancing the company’s reputation and credibility among stakeholders – something on which success or even survival may depend.(Holme and Watts (2000), WBCSD report),

This development in the CSR and environment management approach by businesses in recent years has been influenced by ‘ecological modernisation’ (Utting 2000), the origin of which could be traced to Germany in 1980 due to an observed state-led legislative approach to environment policy and related measures. In later years it progressed to UK, the Netherlands and the rest of Europe (Mol 1999). The theory of ecological modernisation at its heart addresses the environmental reform observed widely in northern European countries. It is referred by Mol (1999) as an analytical framework that helps to understand contemporary environmental reform dynamics. It remains a theory of social change.(For further explanation see Mol 1999 and Mol 2000).

The principle of ecological modernisation has later found its place in many countries' environmental policies and measures, on the premise that environmental protection and sustainability does not have to be built upon an ‚economic slow–down – e.g. Europe, the UK, China, Norway and South Africa (as indicated in Andersen 2002, Revell 2005, Mol 2006, and Oelofse et al. 2006). The influence of ecological modernisation is very much evident at present in the UK climate change programme and the UK Emissions Trading Scheme (Malmborg and Strachan 2005) as **t**he principle of mutual gain for both business and government. The win–win situation associated with the ecological modernisation is able to facilitate governments with their intended policy implementation (Christoff 1996).

In spite of largely favourable concepts of ecological modernisation in sustainable development and CSR/environment strategy and policy, caution is suggested by Berger et al (2001), York and Rosa (2003) and Pataki (2009), who argue that although adaptation of the theory of ecological modernisation to CSR, sustainable development and environmental policy is useful, it does not fully address aspects associated with today's hierarchical power-and-influence structures (in organisations, institutions and society generally) and nor does it address the economic marketplace for individual sectors.

2.3.3 The organisational agenda for mitigation and adaptation

The overall organisational approach to the climate change agenda can be divided into actions for mitigation and adaptation. Because of the importance given to mitigation aspects internationally and at national levels, much of the literature deals with organisations' strategic approaches to mitigation. These approaches in turn give shape to micro-level FM strategy and action within organisations.

Mitigation

In light of the international initiative for climate change mitigation (Kyoto Summit 1997 and the more recent 2009 Johannesburg Summit), governments have set international mitigation targets. These targets have given rise to mitigation efforts promoting legislation and carbon market mechanisms in countries worldwide, and are partly responsible for shaping organisations' strategic approach to climate change.

In the UK, following the fulfilment of the Kyoto targets, the Government has set up renewed targets of a reduction to 80% of 1990 emissions by 2050 in the UK's Low Carbon Transition Plan 2009. The Government intends to achieve this by implementing a mix of policy, regulation and awareness measures.

The measure presently implemented in terms of legislation includes Renewable Obligations, a climate change levy, a UK emissions trading scheme, the Building Regulations 2005, energy performance certificates, climate change agreements and carbon reduction commitments. In recent times the Government has also set initiatives for carbon capture and storage and renewable energy plant systems. Moreover, the Climate change Act 2008 implies a regular accountability to the UK Parliament for action on climate change mitigation and adaptation.

The approach to mitigation outlined above has compelled the public and private sectors to set emission reduction targets and achieve them through a mix of strategic options. The exact composition of such an integrated strategy is company-specific, depending also on the (perceived) risks and opportunities related to climate change and the type of regulation relevant for the industry and the countries in which a company operates (Kolk and Pinske 2005). As Dunn (2002) explains, the financial and services sectors see relatively little legislative and policy risk compared with the industrial and energy sectors; rather, they see the potential for gain by providing services or products to mitigate climate change.

For many commercial organisations the strategic alliances with climate change institutions, along with voluntary disclosure measures, are especially favoured as this helps them to keep abreast with new policy developments and meets the need to be seen as a 'green' organisation, thereby ensuring market standing and customer satisfaction. This is reflected in the carbon disclosure project for the FTSE 500 and FTSE 100 which has seen an increase in the number of new entrants to the projects on a year-by-year basis. The participation of UK FTSE 350 companies since 2006 has risen to 67%, with 47 new entrants, compared with a 49% response at the beginning of the project (CDP 2006; CDP 2008).

These strategic approaches of organisations to be involved in voluntary and CSR reporting, combined with the legislative requirements, requires facilities managers to implement a mix of strategic and operational measures. This is achieved for e.g. through making their operational and property portfolio energy-efficient, through a sustainable supply chain and emission reductions from business travel. The mix of measures as per, Okereke (2007) is achieved by implementing non-fundamental technological and behavioural change, investment in a low-carbon portfolio, and participation in emission trading and offsetting. By carefully selecting from available options, facilities managers can gain a competitive advantage for their companies within their sector and marketplace (Schultz and Williamson 2005).

In spite of the wide array of measures available, barriers exist for implementing mitigation measures in commercial organisations. These include low returns on capital for energy efficiency measures, the time and resources required to research and implement appropriate measures as highlighted by O'Malley et al (2003) and issues relating to the ownership of properties (leased or tenanted) and behavioural and attitudinal aspects of facilities users and organisations (Scrase 2001; Callender and Key 1997, cited in Wilkinson and Reed 2007).

Adaptation

It has been suggested by the IPCC (2001 and 2007a) that adaptation to and mitigation against climate change are complementary and governments should plan for impacts across various sectors. Although initiatives with adaptation have lacked the same impetus given to mitigation, the recent extreme events around the world e.g. Hurricane Katrina in the USA and 2007 UK floods (although not being correlated directly with climate change) have prompted adaptation initiatives by a number of governments.

In the UK, attempts for adaptation are cited in the Climate Change Programmes of 2000 and 2006, the Adaptation Policy Framework and the Adapting to Climate Change Programme 2008. The establishment of UKCIP in 1997 was with the sole intention of providing essential information to stakeholders for planning for the changing climate. The programme has successfully undertaken numerous research activities since then in different sectors, for example formulating adaptation tools such as The UKCIP Business Areas Climate Impacts Assessment

Tool (BACLIAT) and its risk, uncertainty and decision-making framework (Willows and Connell, 2003) which has been recognised by the UNFCC compendium for methods and tools to evaluate the impacts of, and vulnerability and adaptation to, climate change.

Further initiatives on adaptation include the Nottingham Declaration signed by local authorities to address adaptation in partnership with local communities and business, the London Climate Change Partnership, and the BKCC and ARCC research projects for addressing climate impacts and adaptation for the built environment. The UK's Climate Change Act 2008, Planning Policy Statements 1 and 25, and National Indicator 188 (2008) on climate change adaptation are more recent adaptation initiatives, amongst which the reporting requirements of NI188 are now being withdrawn (only establishing the risk assessments of climate change impacts within local authorities). The Adapting to Climate Change Programme under the aegis of DEFRA, as well as the formulation of a Regional Climate Change Partnership (RCCP) and Local and Regional Adaptation Partnership (LRAP) have been established to help the integration of adaptation action at local and regional levels. Under the Climate Change Act 2008 the CCC's Adaptation Subcommittee is responsible for guiding the national adaptation plan by gathering evidence from key sectors and local authorities. These initiatives have increased the awareness and practice of adaptation at local authority level, in public sector and in major infrastructure-managing organisations.

Much of the aforementioned legislation and regulatory framework has been derived for setting public-sector adaptation measures rather than the private sector, and for impacts felt in terms of extreme events such as heat waves or flooding due to heavy rain.

The existing guidance and initiative for housing and SMEs by the UK Government and other institutions for addressing such impacts derives from disaster recovery and business continuity or flood preparation planning, and from flood resilience or resistance measures (EA1, EC1, ABI and NFF 1; no dates). As a result, much of the adaptation action in the private sector is still addressed through business continuity planning.

It has been argued that disaster risk management and business continuity planning are reactive in nature, poorly developed and are not prioritised within an organisation (Gissing 2003; Jones and Ingirige 2008). Drawing on organisational adaptation, Linnenluecke and Griffiths (2010) suggest that adaptation to climate change impacts and related extreme events will require new approaches to be adopted by the affected organisations. In line with this and citing the case of the commercial sector, Jones and Ingirige (2008) argue that although contingency and disaster planning are not new to facilities managers, a much more robust approach to extreme weather events is needed which will take note of the wider supply-chain impact faced by organisations and will improve overall continuous resilience and adaptive capacity.

Furthermore barriers such as a lack of forward planning, access to expertise, individual and organisational attitude, and perceived exposure to risk for developing successful BCP are identified by Jones and Ingirige (2008) after Runyan (2006), Petts (1998) and Yoshida and Deyle (2005), , who also questioned the effectiveness of such instruments in dealing with long-term climate change impacts by facilities managers.

In light of these suggestions it could be said that although measures to address the extreme events exists, they will not be sufficient to address long-term changes and recurring extreme events as a result of climate change because these will differ in nature and intensity from the past historical events experience. For addressing long-term adaptation, facilities managers and their organisations will need to think proactively and develop resilience and adaptation capacities.

2.3.4 Beliefs and perceptions about climate change

Although related to social science and psychology, the study of beliefs, attitudes and perceptions has found relevance in sustainability and environmental action research. There has been much research carried out in the area of public perception on climate change [e.g. the Foresight Report (2010) for the UK Government Office for Science] while the role of individual attitudes and beliefs in addressing climate change and how to influence them has been investigated by Patchen (2006), Grothmann and Patt (2005), Anabel et al (2006), O'Connor et al (1999) and Brody et al (2007). Among these, the work of Grothmann and Patt (2005) has been recognised by the UNFCC as offering distinct value as it puts forward a socio-cognitive Model of Private Proactive Adaptation to Climate Change (MPPACC) which draws from psychology and behavioural economics in coordination with primary climate-change adaptation concepts.

As facilities managers are individuals set in an organisation encompassing a social environment, the study of their attitudes and perceptions is considered important, along with various factors responsible for their actions in relation to the environment and climate change. The managers' awareness of the importance of the environment is highlighted by Brio and Junquera (2002) and Strandholm et al (2004) suggesting that environmental awareness is one of the factors determining the environmental decisions of their organisation, and that managers in different organisations perceive and interpret differently how the environment will impact them.

Although much research has been carried out with regard to organisational and managerial environmental attitudes followed by societal perceptions of climate change, there has been little evidence pointing towards managerial perceptions and beliefs specifically in relation to climate change occurrences which could be responsible for their actions along with legislative and market forces. However, this is found to be altering in recent years. For example, Wittneben and Kiyar (2009) point out an increased awareness of climate change issues in the managerial world and the promotion of climate change education in different academic settings.

Drawing on general risk perceptions and a willingness to address climate change, O'Connor et al (1999) suggested that risk perception matters in predicting behavioural intention and that the behavioural intentions about climate change are complex: *"people are neither non-believers nor complete believers"*. It has also been suggested that recognising the causes of global warming is a powerful predictor of behavioural intentions, independent of belief in climate change. Further more risk perception and knowledge are suggested to share common ground with environmental beliefs and the presence of a 'weak signal' and uncertainty about climate change, knowledge should promote action.

O'Connor (1999) supports Dunlap and Scarce (1991) suggesting that that the attitude to the environment forms the basis of a favourable or hostile approach to environmental risk. Risk perception of climate change and knowledge of its causes will predict an individual's preferences for an approach to climate change. In spite of such suggestions existing research into climate change has focused on how people think about climate change (Brostrom et al 1994, citing Read et al 1994) and not linking risk perception to behavioural intention. Thus from the amalgamation of the existing literature in the field, it could be suggested that risk perception and knowledge together increase people's willingness to take steps that address environmental problems.

Although managers till now have gathered a bank of knowledge for dealing with environmental aspects, much of the action taken by, and imparted on managers is due to environmental legislation, which assumes that a manager's attitude to take proactive action is negative.

Fernàndez et al (2006) citing Ashford (1993) suggests that this restricts a manager’s approach towards fulfilment of the regulation instead of taking a motivated preventive environmental approach which will benefit the organisation.

Dwelling on motivational and commitment aspects it has been argued that managers attitudes towards openness to change versus conservatism is responsible for their ‘intrinsic environmental motivation’ in turn triggering the manager’s expanded environmental efforts., while an altered values-and-belief system are identified as key actors of the organisation necessary to drive environmental efforts. (Fernàndez et al. 2006, Collier and Esteban 2007 citing Fineman 1997).

Finally, Strandholm et al (2004) and Fernàndez et al (2006) conclude that managerial perception, attitude and personal characteristics, along with their organisation’s strategic response and characteristics, will be decisive in any organisational response to environmental aspects. Managers take action for environmental issues depending upon how they relate to them, the external pressures, and how much time and resources the action would attract. In relation to adaptation highlighting a similar contention, Pelling et al (2008) points out that the adaptive behaviour that an organisation manifests emerges from the individual behaviours of its members and the emergence of group behaviour arises from the institutionalisation of the interactions between organisational members.

Highlighting senior managers’ beliefs about climate change in the construction industry, a recent survey by Morton et al (2011) explains that climate change was an important issue for managers and that innovative ways are required for addressing climate change, but at the same time senior managers were of a belief that climate change was a natural phenomenon and current practices were sufficient and mitigation measures were of more importance than adaptation.

Based on the literature regarding beliefs and perception about climate change, this study established that facilities manager’s attitudes towards the environment and their perceptions of climate change would be two important factors in assessing their response for climate change adaptation and mitigation. For this purpose the research has adopted the NEP scale by Dunlap et al (2000) to assess attitudes to the environment and has chosen a set of Likert-scale items to assess the facilities managers’ perceptions of climate change in the questionnaire study.

2.4 Adaptation concepts

Although the case for adaptation to cope with a changing climate has been made by the IPCC, which viewed adaptation as a *"very powerful option"*, little attention has been paid to any possible trade-off between adaptation and mitigation (Pielke 1998, citing IPCC 1996). It is only in recent years that adaptation has started to be noticed as a complementary and crucial approach to climate change (Pielke 1998; Tol et al 1998; Smit et al 2000; Adger et al 2005; Yohe and Strzepek 2007).

The so-called 'domain of adaptation' of human systems could be explained in the context of vulnerability, adaptive capacity, resilience and coping capacity. Smit and Wandel (2006) refer to these as interrelated, and adaptations, as manifestations of adaptive capacity, , resilience and coping capacity, which together represent ways of reducing vulnerability. The following subsection defines each of these three concepts as found in the literature, and are further related to organisational adaptation in particular.

2.4.1 Vulnerability

The IPCC (2007b) defines 'vulnerability' as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity."(Glossary of Terms IPCC 2007b). Adger et al (2005) describe vulnerability as a "state of susceptibility to harm from exposure to stresses associated with environmental and social change and from absence of capacity to adapt". Thus the scale of adaptation of a system would depend upon the sensitivity and exposure of its elements to changing climatic condition or extreme weather. In an organisational context the vulnerability could be expressed as the exposure of an organisation's business functions and assets to long- and short-term climate variability. As O'Brien et al (2004) describe, an organization's vulnerability to climate change and natural disasters is a measure of how susceptible the asset is to damage resulting from disaster events and is a function of exposure, sensitivity and adaptive capacity.

Vulnerability assessment has been part of the risk approach in many organisations in the private sector; but since climate change will expose the business assets within the supply chain, as well as the organisation's own business functions, to different external agents and factors that have been previously experienced, a different approach is required than the one in existence to assess vulnerabilities This is emphasised by suggestions that in spite of a considerable scholarship in a climate change context on calculating indices of vulnerability and adaptive capacities, and on evaluating hypothetical adaptations; the practical applications of this work (in reducing vulnerability) are not yet readily apparent and very few researchers have combined all the factors contributing to vulnerability. (Smit and Wandel 2006, Cutter et al (2008)

The advantage of accounting for contributing factors across all levels and strategies as per (Smit and Wandel (2006) appears to be more effective in reducing the vulnerability. From this it is deduced that while assessing climate-change-induced vulnerability within a commercial setting, it would be beneficial if these are assessed across the entire spectrum of business activities and strategies.

2.4.2 Resilience

The origin of the concept of resilience can be traced to the field of ecology, where Holling (1973) and Walker and Salt (2006) studied the resilience of ecological systems to external disturbance. In order to deal with external or internal vulnerabilities, the concept of resilience has been promoted in various pieces of literature dealing with business and ecology (Gallopín 2006). The IPCC (2007b) defines 'resilience' as *"the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change*". Klein et al (2003), referring to system-specific attributes, describes resilience as *"(i) the amount of disturbance a system can absorb and still remain within the same state or domain of attraction and (ii) the degree to which the system is capable of self-organisation"*. Resilience expands on vulnerability and can be viewed as the quality that enables an individual, community or organisation to cope with, adapt to and recover from a disaster event (Dalziell and McManus 2004). Pointing towards resilience in context of organization, Linnenluecke and Griffiths (2010) suggest that although the concept of organizational resilience is not new, there exists no underlining conceptualisation or frames of reference exist in this field for understanding resilience in the face of climate change and weather pattern shifts.

In terms of organisational response to climate change, resilience could be described as the ability of an organisation to absorb or respond to impacts in a way that will minimise damage and maximise opportunities. Stressing this, O'Brien et al (2004) suggest that an organisation can reduce its vulnerability by enhancing its ability to recover from stress through robust systems. This enhanced ability of organisations to respond effectively will depend, to a large degree, on their organisational structure, the management and operational systems they have in place, and their resilience (Dalziell and McManus 2004).

Stressing organisational and FM responses to the climate–change-induced vulnerability, Warren (2010) points out that organisational resilience can be achieved through risk assessment and the preparation of risk minimisation approaches, which are often, termed disaster recovery planning, crisis management, business impact assessment or business continuity management (BCM). Although these present tools help organisations to recover to a near–to-original (or a predetermined) place, they may be ineffective in combating climate change where return periods of the event are significantly longer than the business planning horizon, whereas per Dalziell and McManus (2004) the development of simple methodologies to evaluate organisational resilience would pave the path forward.

2.4.3 Adaptive capacity

In order to increase the resilience of a system, coping mechanisms are required to ensure successful adaptation. This capacity and ability of a system to plan for coping mechanisms is known as 'adaptive capacity'.

In cases of the increased vulnerability caused by climate change impacts, the level to which a system is capable of surviving will be reliant on its adaptive capacity, defined in IPCC (2007b) as the *"ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences"*. Adaptive capacity will differ by sector, region and nation. As O'Brien et al (2004) put it, in order to achieve climate change adaptation it will be necessary to take account of the vulnerabilities of different sectors and their adaptive capacities in accordance with their location and their change in adaptive capacity over time.

Much of the research related to adaptive capacity has been carried out specifically looking at various indicators and determinants of adaptive capacity at local, regional and national level in relation to ecological and socio-economic systems (Yohe and Tol 2002; Adger 2006; Smit and Wandel 2006; Aalst et al 2008). Very little has been written about organisational adaptive capacity specifically in relation to climate change. The existing literature points towards adaptive capacity as core to business continuity planning and defines adaptive capacity as the ability of an enterprise to alter its *"strategy, operations, management systems, governance structure and decision-support capabilities"* to withstand perturbations and disruptions (Starr et al 2004, cited by Dalziell and McManus 2004).

The IPCC's Third Assessment Report (2001) determined that the ability and capacity of human systems to adapt to and cope with climate change was dependent on such factors as *"wealth, technology, education, information, skills, infrastructure, access to resources, and management capabilities"*. Since organisations are socio-economic entities, similar factors would also be determinant of an organisation's adaptive capacity. Thus in order to mitigate against actual or potential climate variability, it will be necessary for organisations to develop sufficient technical adaptive capabilities and to have the human and financial resources (Liso 2006). The constraint to developing these capacities as defined by Brooks and Adger (2005) is a refusal of key actors to accept the responsibility of risks associated with climate change, where large-scale structural economic factors and prevailing ideologies play a vital role in determining feasible adaptations.

In order to determine the adaptation option through vulnerability assessment and to determine its existing resilience and adaptive capacity, various approaches have been formulated. These assessment approaches are outlined in the remainder of this section and the reasoning for selecting a risk-based approach for the research project is explained.

2.4.4 Existing approaches

The assessment approaches include approaches formulated initially by the IPCC in 1995, the later vulnerability and resilience approach, the risk-based approach applied in the recent past and the present use of explanatory modelling (also known as robustness analysis). This section intends to highlight each of these approaches and present a case for selecting the risk-based approach for this thesis.

IPCC assessment and guidelines

The first set of guidelines and impact assessment methodology were developed by the IPCC in 1994 (Carter et al 1994; Parry and Carter 1998). The approach involved a seven step process:

(1) Defining the problem;
(2) Selecting a method of assessment;
(3) Testing methods;
(4) Selecting climate change scenarios;
(5) Assessing biophysical and socio-economic impacts;
(6) Assessing autonomous adjustments; and
(7) Evaluating adaptation strategies.

The IPCC approach is widely known as a 'standard' approach or top-down approach, where scenarios and global circulation model (GCM) projections are considered and regionalised through downscaling methods to assess the impacts (physical vulnerability). As cited in Burton et al (2002), this approach has generated large amounts of literature in relation to assessment of biophysical impacts being reported in IPCC Assessment Reports.

Since the approach suggested by the IPCC relies heavily on scenario selection (both climate change and socio-economic scenarios), there has been much work done on methods and guidelines for developing and selecting appropriate scenarios. The extensive research carried out in area of impact assessment using the IPCC approach, includes studies done for agriculture, land management, and hydrology and water resources (Menzel 2003 and Yu-pin-lin et al 2007, as cited in IPCC 2007b). Recent studies in the area emphasise the development and use of socio-economic scenarios for impact assessment (e.g. Arnell 2004) and assessment of uncertainty associated with scenarios and downscaling model use (Katz 2002; Dessai 2003).

In spite of the wider use of IPCC guidelines, this use has not generated enough information for decision makers to make sound adaptation decisions. The shortcomings of this approach arise primarily from choosing from a wide range of potential impacts of future climate and associated cascading uncertainty from climate scenarios and socio-economic scenarios, the accuracy issues arising from the application of GCM scenarios to regional and local-level ground conditions and projections for changes in mean and extremes at regional level (Burton et al 2002) Other (secondary) factors mentioned by Burton et al (2002) comprise i) scarcity of consideration of adaptation options other than that suggested by impact assessment; ii) no consideration of obstacles to the adaptation process due to social and behavioural aspect; and, finally, a missing context to the policy for adaptation and vulnerability reduction. As a result of these shortcomings a successive approach with vulnerability reduction, sensitivity and resilience as core elements was considered as forwarding the policy context for adaptation.

Vulnerability and social resilience approach

In contrast to the IPCC quantitative approach, this approach takes a view of community and social capacity to cope with the changing climate or extremes by studying and assessing the vulnerability on the basis of inherent social variables. Contributing to this is the study of the current adaptation to events and climatic changes, considered as a primary point for understanding the process for giving options for future adaptation.

The approach at its heart considers social vulnerability, resilience and options to increase adaptive and coping capacity as a means of formulating adaptation policy (Kelly and Adger 2000; Downing et al 2003).The initiation of the vulnerability research and the effect of available monetary and social resources to individuals and to society has related largely to work first published by Sen in 1981(Janssen et al 2006),.

The argument put forward in these studies proposes a bottom-up approach involving the stakeholder. Here the assessment pointers of vulnerability, responses and capacity to absorb losses or multiply profitability to the present day, or recent historical changes and extreme events, are regarded as the best gauge to understand how society and individuals might respond to future climate change. The added dimension of institutional structure, resource-base, political scenario and societal and individual capacity are noted to improve adaptation policy. This is in contrast to impact assessment studies, which are rendered with inherent uncertainty related to the modelling and projection of future climate change, making it difficult to conjecture responses for adaptation policy with respect to future changes and extreme events.

The extensive research to date with regard to this approach is diverse and has concentrated largely on vulnerability and adaptive capacity and has only recently been found overlapping and merging with the resilience knowledge base (Janssen et al 2006).

The disadvantage with this approach is that in spite of being based on the rich data of experience and measures taken in response to present-day extreme events and changing conditions, it is restricted in its application with future climate changes and extreme events as these may pose different kinds of risk as opposed to today and may or may not result in similar damage or opportunities. Thus the vulnerability approach –although it offers a perfect guide to understand the inherent response mechanism to changes by society and individuals, it cannot completely be taken as a guide to future responses of society to unknown climate change risks.

Risk approach

Throughout the first- and second-generation approaches mentioned above, it was evident that addressing uncertainty related to the climate projection scenario and the sensitivity of the decision made to future changes in climate is the key to appropriate adaptation policies and project-based decisions. Risk assessment and analysis give an opportunity to address such uncertainty and sensitivity related to decision making.

The application of a risk assessment framework and methods to climate change is emphasised by Jones (2001) and Willows and Connell (2003) where Jones (2001) identifies ‘environmental risk management’ (or ‘environmental risk assessment’) as the process of identifying, evaluating, selecting, and implementing actions to reduce the risk to human health and to ecosystems. On the basis of the IPCC impact assessment approach, Jones (2001) sets out the following seven stages of risk assessment (see also Figure 4):

1. Identify the key climatic variables affecting the exposure units being assessed.
2. Create scenarios and/or projected ranges for key climatic variables.
3. Carry out a sensitivity analysis to assess the relationship between climate changes and impacts.
4. Identify the impact thresholds to be analysed for risk with stakeholders.
5. Carry out a risk analysis.
6. Evaluate risk and identify feedbacks likely to result in autonomous adaptations.
7. Consult with stakeholders, analyse proposed adaptations and recommend planned adaptation options.

The importance of the stakeholder’s participation at Stage 4 is specified by Jones (2001) for identifying the impact thresholds, as stakeholders are the best source of information relating to impacts experienced. The key climatic variables are identified in consecutive steps. Based on this the probabilities of variables crossing the stakeholder-defined thresholds in the context of the projected climate-change range are analysed to get the maximum and minimum impact levels.

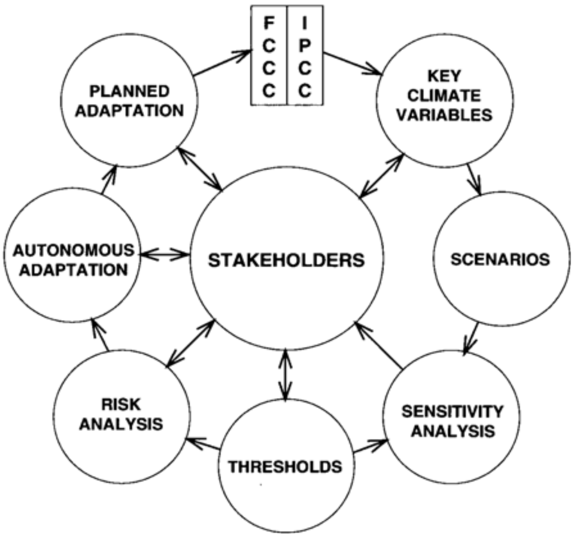


Figure 4: Risk assessment framework for assessing climate change impacts (Source: Jones 2001)

In spite of being stakeholder-focused, this approach is still a scenarios-oriented approach (see step 2), which once again brings forth the difficulty associated with uncertainty in scenario selection and modelling as evident in the previously mentioned approaches. As a step forward in assessment approaches a more generic risk-assessment framework, suggesting minimum exclusive use of the climate change scenario for use of organizational adaptation options and decision making, is proposed by UKCIP.

2.4.5 Approach considered in this thesis and the reasoning

The use of assessment approaches mentioned earlier has been found in diverse studies, ranging from impact studies for water and biodiversity, policy studies (the land management, farming and agriculture sectors) and cost and investment to strategic decision implementations for climate change adaptation. But less has been achieved in assessment and adaptation at the commercial/corporate organisation level. The majority of approaches in this area currently address corporate climate strategy for mitigation approaches and adaptation in terms of how do business in response to increasing legislation and stakeholders’ expectations.

Although much research has been undertaken for climate change impacts and adaptation in the building sector, a considerable amount of this is in relation to residential and new developments. Enquiries on adaptation of existing commercial and corporate built assets, and management buildings (either commercial or residential) have remained unaddressed.

This thesis thus has attempted to study the adaptation of corporate built assets through formulating facilities management strategy with help of available adaptation approaches, tools and climate change data. The study is based on the premise that with the help of available tools and climate change projection data it would be possible to predict future impacts and risk associated for a corporate property portfolio and its management process. Based on above, the facilities managers would be able to shortlist impacts for individual properties and outline related measures (adaptation options) to be included in maintenance and management strategies to ensure adequate performance of built assets for successful survival of the business.

In order to fulfil the research agenda a practical participatory-study-based approach was considered to be most appropriate, as it would offer a reasonable level of interaction with the organisational staff and the facilities management personnel revealing the intricacies associated with using adaptation tools and climate change projections by facilities management professionals.

A proposal was made to a commercial organisation (henceforth the participatory study organisation) and its facilities management department as a result of organisation's early interest in participation with the research project. Based on the review of available adaptation frameworks, tools and techniques (presented in section 2.4.4) the selection of appropriate tools for future risk assessment was made, based on which adaptation measures could be included in future FM strategies.

The following aspects were considered while selecting the appropriate tools: :

- The limited knowledge of facilities managers and organisations about climate change science, its projections models and uncertainty;
- The adaptation framework and decision-making tools which are easily understood and implemented by FM and within the context of the organisation and marketplace; and

- The availability of the data relating to both the organisation’s built assets and climate change projections.

Keeping these in mind and from the adaptation approaches reviewed in the literature, the UKCIP framework for risk assessment and decision making in the face of future climate change was found appropriate for implementation with the facilities management department of the participatory study organisation. The reasons for selecting the framework were:

- Its wider use in business continuity planning decisions, project management health–and-safety issues, disaster management, environmental management and insurance. (Salter 1997; Carreno et al 2007).
- Easy access to the UKCIP framework and guidance, due to its national context and its application it’s use UK based studies.
- The ability of the framework to consider climate change in the context of business risk. (considering climate change as risk additional to other market risks).

2.5 The UKCIP decision-making tool

The UKCIP technical report on climate adaptation and particularly risk, uncertainty and decision making puts forward a framework to support good decision making in the face of climate change (Willows and Connell 2003). The framework and related guidance is intended to help decision makers consider climate adaptation and climate-influenced decisions by identifying risk factors and uncertainty. The stages of the framework are presented as follows (see also Figure 5):

- Structuring the problem:
    - Stage 1: Identify problem and objectives.
    - Stage 2: Establish decision-making criteria, receptors, exposure units and risk-assessment end points.
- Analysing the problem (tiered stages):
    - Stage 3: Assess risk.
    - Stage 4: Identify options.

o Stage 5: Appraise options.

- Decision making:

  o Stage 6: Make decision.

- Post-decision actions:

  o Stage 7: Implement decision.

  o Stage 8: Monitor, evaluate and review.

Although the framework does not include the design of scenarios and projections exclusively in any of the stages, it's use is promoted as a tool at the stage of risk assessment (Stage 3) which is a tiered stage.

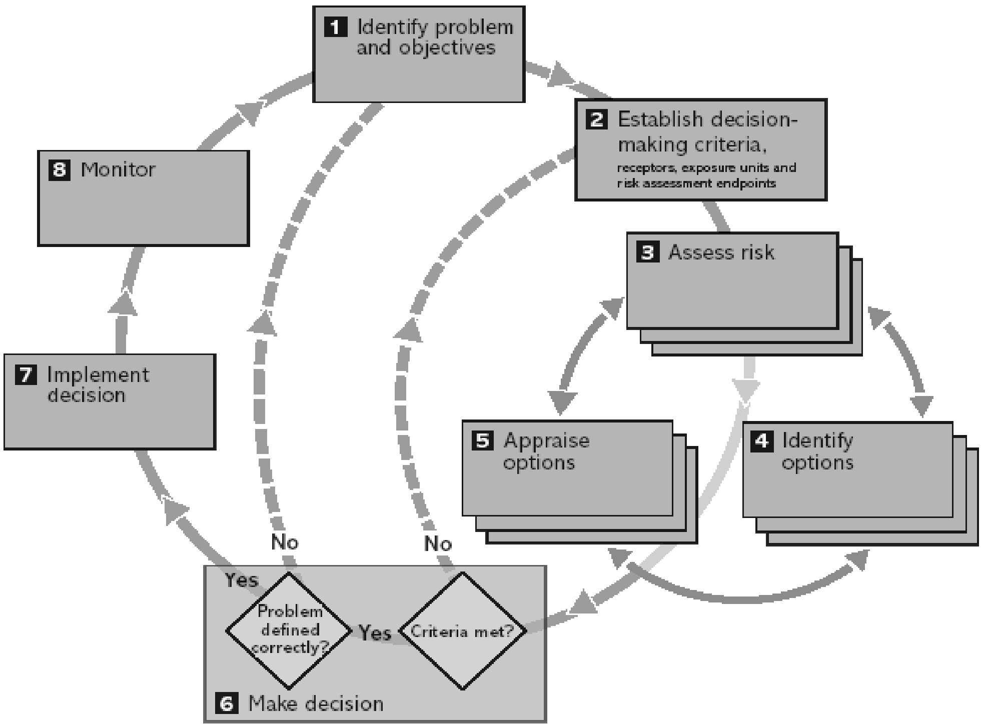


Figure 5: A framework to support good decision making in the face of climate change risk (Source: Willows and Connell 2003)

The tiered stage of the risk assessment at Stage 3 involves identifying the climate variables (temperature, precipitation etc.) which represent potential impacts and is followed by a qualitative screening of risk and uncertainty associated with them. A more quantitative analysis is proposed (higher-level uncertainty and sensitivity analysis) for quantifying the risk. The framework thus implies the use of scenarios and projections relative to and in accordance with the decision makers' and stakeholders' knowledge and the level of decision making (i.e. policy, programme, and project).

The UKCIP framework is unique in its approach as it considers climate change as an addition to the risk posed by external and market forces to the decision maker, and in doing so it provides flexibility of use of climate change scenarios and projections as per the decision makers' requirements. The suggestion for uncertainty analysis in quantifying risk helps the decision makers in reaching a robust decision in the light of climate change. This is emphasised by the UNFCC compendium that identifies the framework as being distinctive in casting the assessment process in risk and decision under uncertainty terms.

2.6 Organisational contextual theories used for deriving conclusions

Since the present research was undertaken with a commercial organisation, in order to draw on the results and make conclusions, organisational decision making and organisational learning theories were referred to as contextual theories. Organisational decision making, which is described in subsection 2.6.1, has been used to understand the decision-making process adopted by the facilities management team while implementing the UKCIP decision-making framework while the organisational learning concept is outlined in subsection 2.6.2. This concept has helped in understanding the process and aspects which the participatory study organisation has adopted for considering future adaptation to climate change impacts.

2.6.1 Organisational decision making

Since decision making is an integral part of the UKCIP risk and decision-making framework, it was decided that a conceptual understanding of decision making and its different perspectives would help forward the discussions arising from the implementation process and consolidate overall conclusions. The following paragraphs define decision making, together with its various approaches and models, in brief.

Decision making is the process of making choices from among two or more alternatives, which is influenced by political processes, the power exercised by the individual making the decision, and the tactics used to gain advantage (Knights and WiIlmott 2007; Buchanan and Huczynski 2010).

The decision making within an organisation as described by Buchanan and Huczynski (2010) can be undertaken at three levels, as individual, group and organisational. Within these groups mainly two types of decision process occur, namely structured and unstructured (McKenna 2006). The structured approach uses perspective-normative models where linear statistical methods are used (e.g. Bayesian theory) and the method is more concerned with the process followed by the individual or a group (McKenna 2006). Buchanan and Huczynski (2010) associate this approach with the classical view where empiricism and positivism is supported through logical reasoning and argument. The logical reasoning and methods formulate part of an organisation's structured way of solving routine decisions.

The structured approach has a limitation as it does not account for individual cognitive influences, information processing abilities, attitudes and behaviours. These aspects are considered in cognitive, bounded rationality and descriptive models (McKenna 2006). These descriptive models play an important role in unstructured decision making, which in essence is a type of decision making where the decisions have to be made in the presence of uncertainty and risk – i.e. where there is a lack of information to estimate likelihood of outcome and associated payoffs (McKenna 2006). Descriptive models take into consideration individuals' ability to process information and the way they make decisions is influenced by following six factors (Buchanan and Huczynski 2010):

- Individual personality;
- Group relationship;
- Organisational power relationships and political behaviour;
- External pressures;
- Organisational strategy; and
- Information availability.

The approach also recognise that for a particular decision (a) the definition of a situation is likely to be incomplete; (b) it is impossible to generate all alternatives and predict all outcomes; and (c) final decisions is likely to be influenced by personal and political factors. As a result of these aspects the descriptive models as per McKenna (2006) uses three main processes to arrive at a decision:

- It considers alternatives in sequential fashion;
- It uses heuristics to identify the most promising alternatives; and
- It assumes that decision makers consider one alternative at a time and choose the option which satisfies the maximum number of criteria set.

Noting the use of heuristics in descriptive models, it has been argued that use of heuristics in some cases cause users to be biased towards inherent human intuition which in spite of complementing systematic analysis are virtually undetectable. Thus for adaptive decisions attention should be given for a balanced use of heuristics and quantitative decision tools.(Buchanan (2010), and McKenna (2006)

In addition to heuristics the unstructured and adaptive decisions are also influenced by the decision maker's approach – for instance whether the individual is 'divergent' or 'convergent', what their decision style is, and the culture of the organisation. The five stages of decision making to be considered in the context of organisational culture, referred by McKenna 2006 are:

1) Problem recognition – problem solving is proactive in some cultures;
2) Information search – some cultures promote more fact gathering then others;
3) Construction of alternatives – future-oriented cultures will seek more alternatives;
4) Choice – organisational culture dictates the level and speed at which decisions are taken; and
5) Implementation – The structure and culture of the organisation will determine the speed and accuracy at which the implementation is made.

While, a divergent individual is expressed as individual who is able to explore more avenues to problem solving and thus will be involved in creative and innovative decision making, where a novel way of doing things is sought. Amongst the eight different style of decision-making i.e. Sensation thinking; Sensation feeling; Intuition thinking; Intuition feeling; Analytical; Directive; Conceptual; and Behavioural, the divergent individual is likely to adopt sensation feeling, analytical and conceptual style as these are able to address uncertainty, collect more information and seek a long-term view with more alternatives and creative solutions (McKenna 2006).

The aspects of decision making outlined above i.e. the type of decision (structured or unstructured, with the possible presence of uncertainty) and the peripheral conditions (individual style, and the cultural and structural setting of the individual's organisation) were referred to, while observing the participatory organisation's decision making process.

2.6.2 Organisational learning

Amongst the limited literature found in the area of private sector adaptation attempts to relate private-sector adaptation to organisational learning. It claims that the adaptation process in an individual organisation is closely related to the concepts of organisational learning, and that the culture and behavioural aspects of the organisation has a considerable input into the process (see, for example, Berkhout et al 2006; Pelling et al 2008; Wilby and Vaughan 2011; Boyd and Osbahr 2010).

In light of this limited literature, the basic concepts of organisational learning were referred to for the purposes of final discussions and conclusions (see Chapters 9 and 10). The following paragraphs attempt to set out organisational learning based on definitions from various pieces of literature and its association with other aspects of the organisation.

Organisational learning concepts have been cited in literature since 1980 and its application as per Wang and Ahmed (2003) should be looked at in the context of organisational strategy, culture, absorptive capacity, and structure and employee participation where different perspectives has been provided on the subject by Levitt and March (1988), Senge (1990) and Argryis and Schon (1996). From amongst these perspectives the view by Argryis and Schon (1996) and Levitt and March (1988) are cited in the organisational adaptation literature. According to Argyris and Schon (1996), organisational learning occurs when individuals in an organisation experience a problematic situation and enquire into it on their organisation's behalf Learning involves the encoding in organisational routines ,the lessons learnt from problematic situations, . This process altering routine, leads to changes in organisational behaviour and is referred to as adaptation Berkhout et al (2004).

Kloot (1997) after Senge (1990) and Argyris and Schon (1996), relates adaptation occurrence at two levels of learning: *"1) Related to the learning enough to allow the organisational survival (single loop learning) which does not require major change and 2) generative or fundamental learning (double loop learning) which enhances the capacity to create new paradigms"*. Kloot (1997) insists that organisational learning requires double-loop learning practices, which is associated with the four major constructs of organisational learning, namely knowledge acquisition, information distribution, information interpretation and organisational memory. With a similar emphasis Berkhout et al (2004), after Winter (2002), describe the stages of the organisational learning cycle as signal recognition and interpretation, experimentation and search (likened to knowledge acquisition, information distribution and information interpretation), knowledge articulation, and codification (embedded as organisational memory).

It has been suggested that these constructs and stages of organisational learning are in turn affected by management control systems and organisational culture and strategy. Organisations are considered as social systems where structure and culture shape the learning within them and management structures influence the constructs of organisational learning, especially knowledge acquisition and distribution. (Pelling et al (2008), and Kloot (1997) .Emphasis has been made on collaborative cultures, which encourage deeper (double-loop) learning in the organisation. Lopez et al (2004), Pelling et al (2008) after Elwyn et al (2001), The four ways in which culture influences the behaviours central to the knowledge creation and distribution aspect of organisational learning defined by Delong and Fahey (2000) are presented in Figure 6.

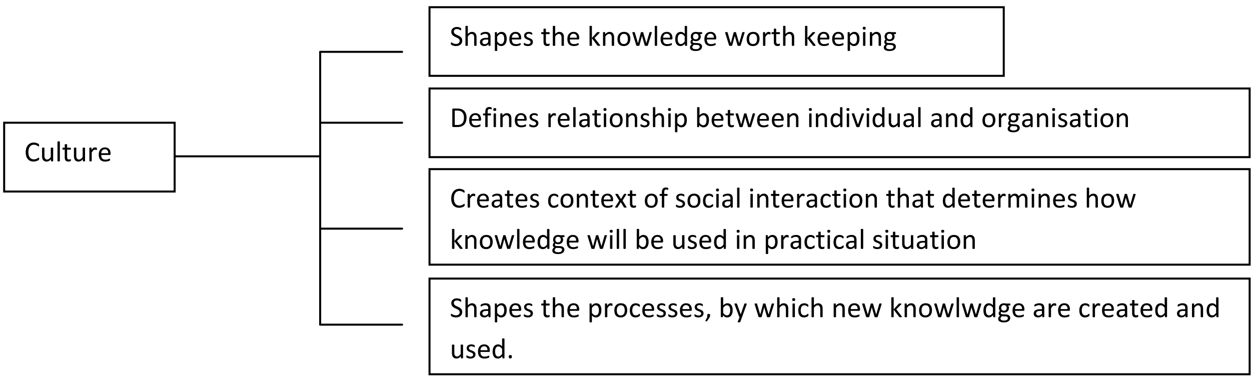


Figure 6: Culture influencing knowledge creation
(derived from an explanation based in Delong and Fahey (2000))

The perspective of organisational learning mentioned above helps to see organisational adaptation as a process of organisational learning. This distinction, along with factors identified by Berkhout et al (2004), are referred to while drawing conclusions in Chapter 9 and the emerging application of concepts of informal learning, shadow networks and social interaction to adaptation and adaptive capacity-building, as highlighted by Wilby and Vaughan (2011), Pelling et al (2008), and Boyd and Osbahr (2010), are also acknowledged.

2.7 Chapter summary

This chapter has assimilated various subject areas in relation to the present research. In doing so it identifies the associations and gaps, which form the basis of the research questions and objectives. The six significant aspects identified are as follows:

1) Climate change will have physical and operational impacts on businesses and their built assets, which represent future risks to business function. A facilities manager, as a manager of business requirements, built assets, would be required to respond to these risks.

2) The present maintenance and FM strategy models do not predict demands more than five years into the future and thus are not responsive to the risks posed by future climate changes to existing built assets over a longer time frame (20 to 30 years). In light of this a new approach is required, which can allow facilities managers to assess future risk on their organisation's existing built assets arising from climate change, and integrate adaptation options into their FM and maintenance strategy.

3) Many approaches exist that assess the impacts of climate change but in the UK context, at the time of study the climate change projections (UKCIP02) and the UKCIP risk and decision-making framework were identified as useful tools to assess the risk and evaluate adaptation options for businesses and public-sector entities. Adoption of these tools to support the new approach for facilities managers to assess risk to their existing built assets presents a valuable research avenue.

4) The understanding that an organisation's approach to climate change is influenced by legislation and financial and market forces offers an insight into existing FM action for climate change. The distinction of wider adaptation concepts such as adaptive capacity and resilience in an organisational context offer the basis for FM adaptation choices.

5) The contextual theories from management sciences, especially organisational learning and decision making, offer valid references as to how the businesses address adaptation. They also provide an outline of how the cultural and structural aspects of an organisation affect the learning and adaptation process.

6) The wider literature on addressing climate change also identifies individual perception and knowledge as a contributing factor for addressing mitigation and adaptation actions.

Chapter 3 Research methodology

This chapter introduces the philosophical premise adopted for the research study in section 3.1 and outlines the selected research method design in section 3.2. Section 3.3 presents the qualitative approach for participatory study design, data collection, and analysis and validation aspects. The section is divided into two parts: the first deals with the participant observation study where the UKCIP decision-making framework in implemented; and the other deals with the limited number of interviews and the analysis of strategic documents for setting the contextual factors. Subsequently Section 3.4 details the quantitative approach for questionnaire design and analysis and Section 3.5 summarises the chapter.

3.1 Philosophical premise

Every research methodology has its underlying set of beliefs or ontological and epistemological bases that guide the research (Creswell 2009). These are also often known as paradigms. These paradigms are based on many aspects such as the research area, researcher's and adviser's belief etc. The different paradigms described ranges from positivism to post-positivism, social construction and pragmatism.

The positivist stance is attached to scientific research, which is more likely to adopt a quantitative methodology while the post-positivist holds the belief that a study of actions and behaviour cannot be purely scientific. Thus the results from a post-positive approach provide a measurement of the objective reality. The social constructionist takes a stance that the individual develops subjective meaning for the world and situation in which they live and the study of this complex view of an individual or their experiences is essential. This favours the qualitative methods and open-ended questions and interactions (Creswell 2009).

The philosophical stances mentioned above are associated with distinct methodology (qualitative or quantitative) and are anchored at opposite ends of a spectrum. In contrast, a definitive middle position is assumed by pragmatism, which agrees with the positivists' and post-positivists' belief in an objective reality but at the same time disagree with an absolute truth. The pragmatic position asserts that the research question is fundamental and the various research methods should be used to answer the research questions. It agrees that the research questions in much research are combinations of questions and could be best answered by adopting a mixed-method approach. The logical inquiry in pragmatism includes the use of induction (or discovery of patterns), deduction (testing of theories and hypotheses) and abduction (uncovering and relying on the best of a set of explanations for understanding the results) (Maxwell 2005).

The pragmatic paradigm allows the use of quantitative and qualitative methods in social and behavioural research. As the built environment draws from disciplines of engineering, social and management sciences and business research (Fellows and Liu 1997, cited in Amaratunga and Baldry 2002), and since business research is a form of social and behavioural research (Easterby-Smith et al 1991, cited in Creswell (2009) there is every reason to believe that pragmatism is applicable as a paradigm to business and built-environment research. Since the present research deals with research in the business and commercial context and requires answering a mix of research questions, a pragmatic approach is adopted. A sequential mixed-method strategy was cited as appropriate whereby findings of one method (a qualitative participatory-study approach) is expanded and supported by the findings of other method (quantitative questionnaire survey) (Creswell 2009).

3.2 Research design and methods

The overall research design and methods have been derived with reference to Maxwell (2005) and Johnson and Onwuegbuzie (2004). The basic components presented by Maxwell (2005) for qualitative design refer to goals, the conceptual framework, the research question and methods and validity.. The research method is adapted from the mixed research process model (see Figure 7) after Johnson and Onwuegbuzie (2004) as a pragmatic stance and a mixed-method approach is favoured for the study. The validity aspects are noted separately for both qualitative participatory study and the quantitative questionnaire survey.

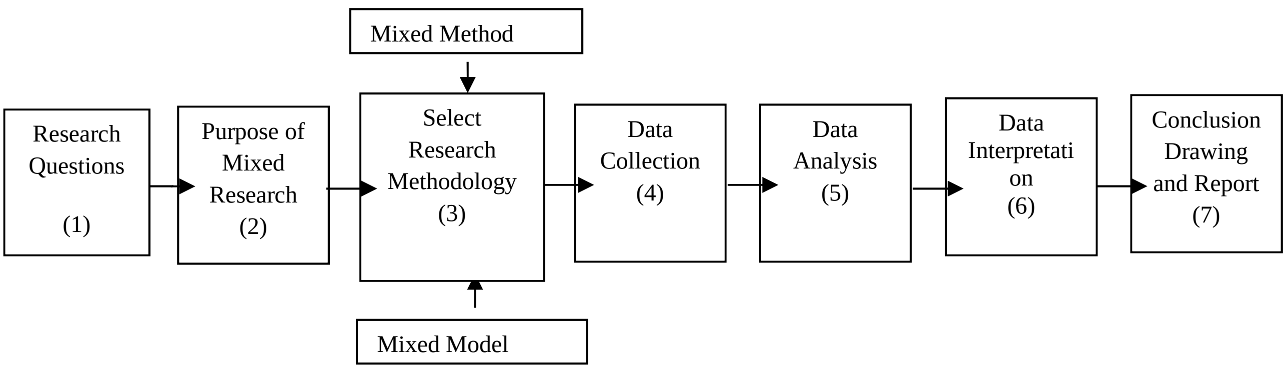


Fig 7: Thematic mixed research process (adapted from Johnson and Onwuegbuzie 2004)

As mentioned earlier, the present study has followed a sequential mixed-method strategy. The qualitative participatory study of the commercial organisation was carried out to answer the primary research question of ‘‘How can an existing risk assessment framework and climate change projection (UKCIP02) be applied to translate climate change impacts into built-asset-level risk in order to support maintenance and business-level decision making in a private-sector business? This required studying the UKCIP risk-based decision-making framework implementation with a facilities management team.

The study made observations on (a) the overall exposure assessment of the built assets to the extreme and changing climate and (b) the resulting adaptation process. The observed adaptation process was seen to be influenced by organisational contextual factors and also by the opinions and perceptions of the participating team members. Both of these aspects were studied through observations and informal interviews, which gave an insight into the subjective and situation-based views and perception of the participants.

The participatory study also outlined the barriers and facilitators in terms of contextual factors and from the participants' subjective responses. Since findings were in this instance confined to one organisation, in order to gain a broader perspective on the issue and confirmation of the findings, a quantitative questionnaire survey of the wider facilities management population in the UK was undertaken. In addition to confirming the results, the questionnaire supported the initial objectives of (a) identifying current FM strategic approaches for CO_2 reduction and for inducing resilience into the commercial built-asset stock and (b) identifying influencing factors affecting CO_2 reduction and resilience measures in commercial built assets. The research method model developed for the study is illustrated in Figure 8.

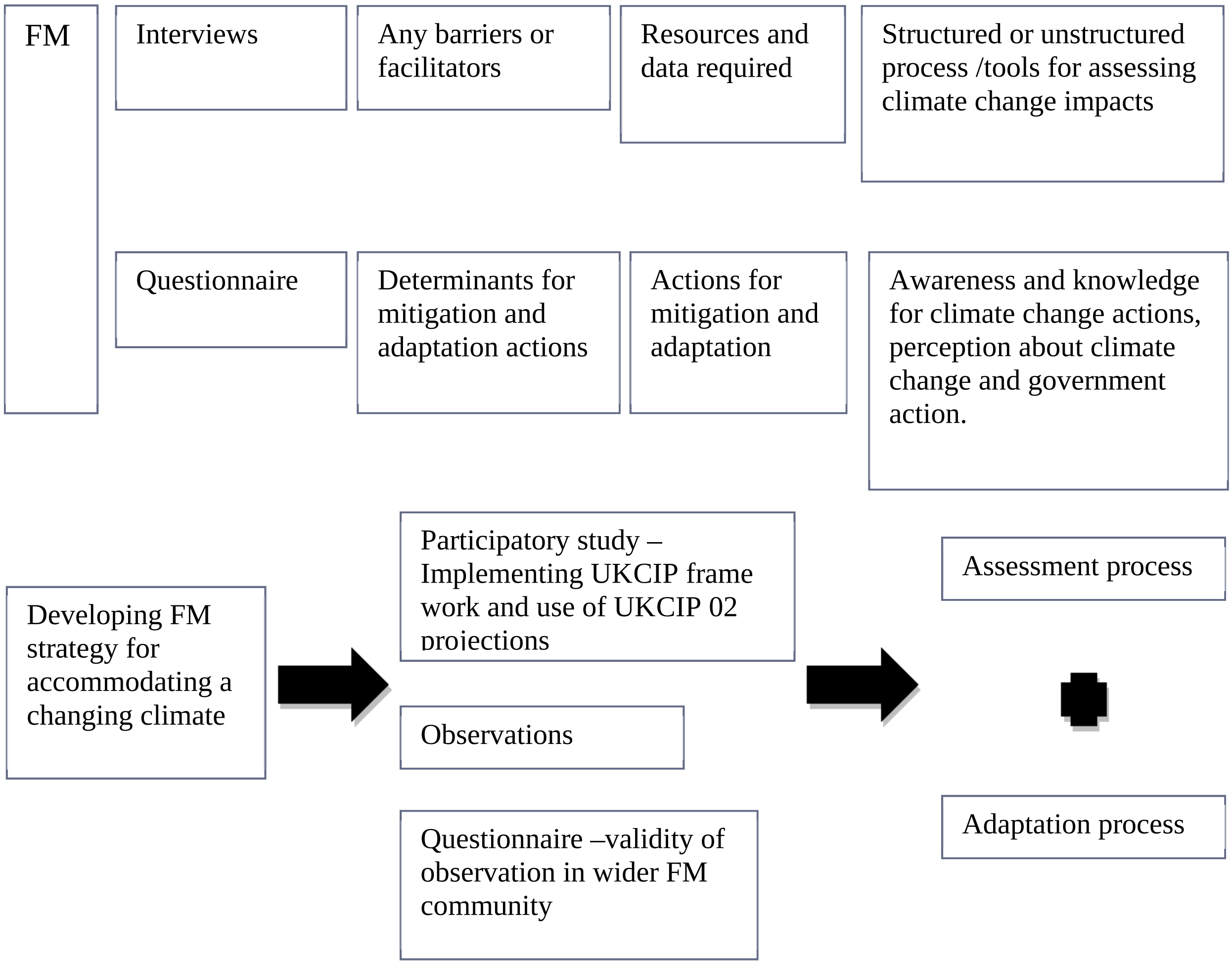


Fig 8: Research method model

3.2.1 Applicability and validity

The research deals with one participatory study and attempts to achieve the objectives mentioned in Chapter 1. Although the questionnaire survey helps to confirm the results achieved through the participatory study in wider facilities management population, it cannot be considered as a generalised finding for all commercial organisations as each organisation differs in terms of its business sector, behaviour and culture.

Since there is very little research carried out on the subject of making commercial built assets resilient to climate change through adaptive facilities management, it was necessary to test the suggested concepts of this research on a single entity. Thus in an attempt to answer the research question, this study has taken a singular approach (Maxwell 2005) and has undertaken a participatory study of one commercial organisation from the service sector. The author's hope is that the findings will lead to wider research on commercial built-asset adaptation to climate change.

Findings from a singular study always face the issue of external validity (knowing the extent to which results could be generalised) but at the same time such a study has an advantage over the survey method and multiple study cases where the researcher is able to access unique and most relevant information (Yin 2009). This is the case in present study. The findings from the singular participatory study could also be applicable to cases with a similar context – leading, for an example, to a generalisation that legislation, finance and corporate social responsibility factors will always be the deciding factors in taking action for either mitigation or adaption. These generalisations are assisted through the study of contextual factors affecting commercial facilities managers.

3.2.2 Ethics

Ethical issues in research could arise in specifying research questions, or in collecting and analysing the data (Creswell 2009). Within present research, these issues arise on the part of the researcher while engaging with a commercial organisation in specifying the research question and in data collection. This was resolved by developing a cooperative relationship between the key representative of the organisation and the researchers. The central research question was derived from the initial research proposal in collaboration with these key personnel.

For resolving issues with data collection, a reciprocal structure was created whereby the data pertaining to the organisational strategy and targets was collected after consultation with the key organisational representative. This responsive approach was also maintained with the facilities management team members participating in the case study whereby, at the end of every stage of the risk-based framework implementation process, the observations and conversations noted for the purpose of the research were sent back to the participants for confirmation.

Anonymity for participants and the source of strategic documents was maintained throughout the analysis and reporting stages of this research. Also, no findings have been made public without prior permission from either the participant or the organisational authorities.

3.3 Qualitative studies: Participative study observation and interviews outlining contextual factors

The aim of the qualitative study was twofold. The first was to observe and identify the process of implementation of the risk-based UKCIP tool with the team of facilities managers. This helped in answering the primary research question of how to generate a long-term climate adaptive facilities management strategy using available risk assessment frameworks and climate change projections. The second objective of the study was to identify the internal and external contextual factors affecting the mitigation and adaptation actions of facilities managers within the commercial organisation.

The observations made while implementing the UKCIP decision-making tool are presented in Chapter 5 while the identification of the contextual factors is reported in detail in Chapter 4, which also give background information on the participating organisation.

3.3.1 Methods

Yin (2009) mentions six sources (i.e. methods) of evidence (i.e. data) collection used in the study of individual cases, namely documentation, archival records, interviews, direct observation, participant observation and physical artefacts. Among these, the two methods of direct observation and participation observation have long been used in the social sciences and organisational research (Cassell and Symon 1994).

In order to answer the research questions and gather the required data, the present study has collected data from organisational strategic documents, informal interviews and participant observation study. The strategic documents and the informal interviews have helped in identifying the organisation’s overall environmental approach and contextual factors responsible for the organisation’s advancement over time in addressing mitigation and adaptation issues. The informal semi-structured interviews were adopted to encourage the discussion of relevant contextual factors other than the ones identified from the literature review.

The participating organisation’s facilities and workplace operations department was involved with the research from April 2006 to April 2007. Later involvement was not possible due to the emergence of the worldwide financial turmoil and especially because the participating organisation belonged to the banking sector. The impact of such turmoil on the research could have been explored in detail but this would have taken extensive time and resources, which were not possible during the period. This point is discussed in more detail in concluding Chapter 9, where suggestions are made for such studies to take the form of further research.

During the period of the organisation's close involvement in the research, there were four meetings involving six workplace (facilities) management staff for the implementation of a UKCIP framework and for introducing UKCIP02 climate change projections. This arrangement generated the observations and informal discussions that form part of Chapters 4 and 5. The organisation's internal and external context was examined through four semi-structured and phone-based conversations. In addition, six strategic and three external proposal documents were examined – these were not publicly available and were only provided because of the organisation's involvement in the research project. As a result of this study, the research team also had an opportunity to represent the organisation in one external event and generated two intermediate reports to the organisation.

At the beginning of the study, the actions for climate change mitigation and adaptation planned by the participating organisation, together with the reasons for undertaking such actions, were established through an analysis of the strategic documents and through interviews with four facilities and operational maintenance personnel (see Appendix 1). The questions for the semi-structured initial interviews were based on the concepts identified from the organisational theory base literature addressing internal and external contextual factors, as outlined in Chapter 2. The semi-structured interviews and the phone-based conversations were documented immediately after each event. A recording device was not used in these interviews to ensure the confidentiality of all organisational strategic disclosures.

3.3.2 Analysis

Analysis was carried out of the data gathered through interviews and strategic documents. The strategic documents were referred to for planned and past measures and targets. Three time periods were identified:

1) An initial phase, where the organisation had started to take actions towards climate change and sustainability as whole;

2) The action undertaken during the research period; and

3) Targets as well as actions planned for the future. This approach was used to determine the pattern followed by the organisation..(A chart relating to these time series can be found in Appendix 2). The data drawn from the strategic documents also helped in triangulation of data received from organisational staff in interviews and the UKCIP framework implementation process.

The study has taken the template analysis approach suggested by King (1998), cited in Cassell and Symon (1994) for analysing interview data. This approach places itself in between content analysis (where the codes for interview analysis are predefined) and the grounded theory approach (where the codes are derived from the data (King 1998, cited in Cassell and Symon 1994). As per the approach, a set of *a priori* codes are identified from the theoretical background and are further developed through the interview content. The contextual factors in the present study were thus identified by the researcher referring to the literature outlined in Chapter 2. These factors were set as *a priori* codes. The interview data was added to this identification during the analysis stage, giving rise to a hierarchical set of coding templates. Since no recording device was used during the interview process, the notes taken during the interview were transcribed at a later stage.

The data analysis went through following stages, as adapted from King (1998) (, as cited in Cassell and Symon (1994) and Sapsford and Jupp (2006) :

- **Data familiarization and transcription** – This involves familiarising oneself with the interview notes and expanding or transcribing the same. The process helps in identifying overall interview content and correcting any errors during transcribing phase.

- **Primary coding –** During this stage the content related to the *a priori* codes are identified and coded accordingly. There were in total eight *a priori* codes identified from the literature.

- **Identifying new themes/factors –** At this stage the interview notes are referred to for identifying any emerging factors additional to *priory codes*. There were two additional (*post priori*) codes identified from this phase.

- **Verifying the factors (codes) –** For this stage the ten *priori* codes were discussed with a member of the facilities team who was involved in the interview. This was to ensure that no additional factors remained unidentified. Diagrammatic charts of these codes were discussed with the research guide to ensure validity.

- **Developing a template –** A template is developed after identifying the *a priori* and *post priori* codes. The interview notes were referred to once again and new codes were added wherever necessary. Thus at the end of this stage there were a total of sixty three codes identified, which were then arranged in a hierarchical array. The ten *priori* codes were placed at the top of the hierarchy and the rest were arranged in clusters as per their associations, fitting to the *a priori* code categories. This produced a three-tiered coding cluster where each *a priori* code included two or three sub-codes, which in turn included other explanatory coding terms. The final coding template can be seen in Appendix 3.

- **Writing up the findings –** The findings of this analysis are presented in Chapter 4 where the participating organisation is being introduced with help of the contextual internal and external factors and each factor is elaborated with help of interview conversation notes.

3.3.3 UKCIP framework implementation – participation observation study

The observations in the research study were carried out to gain an understanding of the significance that specific activities have for participants, or simply to see 'how things happen' (Blumer 1969, as cited in Gibson and Brown 2009). Observation studies as per Sapsford and Jupp (2006) can be undertaken to collect quantitative data on incidence occurrence, to obtain a qualitative description of behaviour and the culture of a group or institution or to test particular theories and situations. In the present research, the participatory observation study was undertaken to test the applicability of the suggested concept of generating a long-term climate-adaptive FM strategy, and to identify barriers and facilitators for FM teams when generating such strategies. In this context the observation study tests the application of the UKCIP framework with the participating organisation, understanding a case along with the influence of the contextual aspects on application of the framework.

The two distinct types of observational research defined by Gibson and Brown (2009) are known as 'structured' and 'unstructured' observational research. Structured research has a well-defined observation schedule where the researcher is looking for evidence confirming predefined aspects and practices. The aim of structured observation is to produce quantitative data in examination of relationships, behaviours and patterns (Sapsford and Jupp 2006). In contrast, unstructured research works in an iterative way to find out about particular practices and aspects. In the unstructured approach the interest is worked through the context (Gibson and Brown 2009). The main technique used in such a study is participant observation, where the researcher participates in the study to a certain extent to understand the contextual factors and makes observations. These observations are combined with interviews, conversations and are recorded in field notes (Sapsford and Jupp 2006).

Since the UKCIP framework implementation process within the participating organisation was a newly introduced practice during the research period, it had no predefined behavioural or contextual aspects for which confirming or opposing observations could be made. The unstructured observation was therefore found appropriate in this situation and could contribute to understanding the way in which the implementation process was carried out by the participants and the nature of participants' responses during the entire process.

The approach helped further in answering two primary research questions: 'How can the organisation achieve a climate-adaptive FM strategy?' and 'What are the barriers and facilitators that help an FM team use the projections and the tools to generate such a strategy?' The participant observation technique was adopted, which meant that the researcher became a part of the process whereby the UKCIP framework stages and UKCIP02 projections were explained by the researchers and the process was facilitated by regular input if required or requested by the participants – thus confirming the role of the researcher with minimum disruption to the actual process. The informal conversation during the study also added to the observation made.

During the participation observation study of the UKCIP framework implementation with the team of workplace (facilities) management staff, observations were made on the team members' responses to individual stages of the framework. The outcomes for each stage were given to the team members in the consecutive stages and at the end of the entire process. This process identified the limiting and promoting aspects of the UKCIP framework implementation in use of the UKCIP02 projection, and observed the built-asset exposure assessment and resulting adaptation process. It also helped in generating an overall agreement within the participating organisation to address adaptation and mitigation and formulate an initial strategic adaptation response for the built-asset portfolio. The internal contextual factors affecting the adaptation approach were revealed during the informal conversations with team members.

All the observations during the UKCIP framework implementation process were documented in note form as each stage progressed and were fully transcribed at a later stage.

3.3.4 Analysis

In an observation study, researchers need to make a practical distinction between what happened (description) and what they think about what happened (analysis or interpretation) (Gibson and Brown 2009). Following this distinction, implementation of a study includes two distinct sections: (a) a summary of the result of each stage (description); and (b) the observations made about each stage by the researcher (analysis).

Since field notes are a way for researchers to think through the setting and its analysis (Gibson and Brown 2009), the research under discussion relied on the field notes taken during the implementation process, which were a mix of small quotes, conversations and the researchers' own thought processes. All the notes were transcribed as soon as possible during and after the implementation process.

The analysis of the data thus collected followed the following steps:

- **Step one – Written field notes, questions and answers and concerns (if any) of the participant.** During the initial introduction and subsequent application of each of the UKCIP framework stages, brief descriptive notes were made pertaining to what happened and the questions raised or debated. These were later used as a feedback to the team before embarking on the new stage.
- **Step two – Writing observation notes after each stage.** Short observational notes were formulated after each stage, which included the researcher's reflection on the participant's response to the particular stage and their concerns if any.
- **Step three – Familiarisation with the notes.** The descriptive notes and observation notes were read through to familiarise the researcher with the overall content and the emerging themes. This step also helped in correction of any errors made in recording the notes.

- **Step four – Identifying the issues.** By comparing descriptive and observation notes on the emerging concerns of the participants with the UKCIP framework and UKCIP02 projection, an overall approach for adaptation was identified.

3.3.5 Validity

The issue of validity in research data deals with accuracy and reliability of the data gathered. With observational studies, Sapsford and Jupp (2006) report threats to validity arising from the possibility of reactivity, inadequacies of measuring instruments, observer bias and misconception, and misinterpretation of the behaviour noted. These threats are addressed through triangulation and respondents' validation.

The threat from reactivity was kept to a minimum because the involvement of the researcher, though intensive, was only for a short period of time and during this period the researcher did not attempt to change the organisational situation but, rather, observed the changes which had occurred and study the implications of introducing a new process within the facilities and operational environment. In addition, the issue of researcher bias was addressed by discussing the overall observations with a senior research guide and a research colleague.

Other methods of replication of the study and re-study were not applied due to time restrictions with the participating organisation. Also, comparison with similar settings was not possible to gain as no such study was cited during the period of research within the literature or by the participating organisation.

Triangulation involves cross-checking the data from the observation study with other sources such as documentary evidence, interviews and conversations. The observations and data collected from the implementation process were related to the data gathered from the initial interviews and informal conversation notes agreed with the participants.

Respondents' validation involves comparing data gathered by the observer with the data received from the participants involved. This was achieved in the current study by presenting observation notes to the participant at the start of each new stage in the implementation process and also at the end of the study. The observations made were discussed with the participants during informal conversations to establish their agreement or disagreement on the same.

In addition to the validity aspect, Sapsford and Jupp (2006) highlight many advantages and disadvantages of the observation study. The advantages of an observation study include direct involvement, resulting in data accuracy which in turn permits insights and supporting data for other findings.

In contrast, the disadvantages include limited access to sites and participants, changes in participant behaviour because of the observation being made, observer bias and observation of a restricted range of subjects. The mitigation strategies adopted for overcoming these disadvantages are as follows:

- **Limited access to sites and participants –** This was not the case in the present research project as complete access and familiarity with the participants and the FM team was gained both before and during the study period.
- **Change in participants behaviour due to observation being made –** This situation was a very rare occurrence in the implementation study as the researcher became a part of the process from the beginning of each stage, which made the process open for discussion and input, thereby reducing the chances of any 'conscious' behaviour.
- **Observers' bias –** to minimise this aspect, the observations and the results of each stage were provided for the participant's reference. Doing this avoided any misinterpretation in observation description.
- **Observation of restricted range of subjects –** Since the observation was made during a single case, the representativeness of the analysis was restricted. To support the findings of the single-case observations, the later stage of research involved a questionnaire survey to confirm the findings from the participatory study with the wider facilities management community.

3.3.6 Methods not employed

The avenue of so-called 'action research' could have been adopted instead of the participant observation study in implementation of the UKCIP framework, but it was not considered fitting to the study because carrying out an action research which followed a continuous cycle of response and feedback was deemed time-consuming and also would have required additional dedicated resources on the part of both the researcher and the organisation.

The contextual factors derived from the literature and consecutive interviews had the potential for adopting a focus group approach, but once again the time constraints presented by the participating organisation was a restricting factor.

In spite of these methods not being implemented, the study was able to gather the data required to answer the primary research question and objectives. The organisation participation achieved was short but intensive, revealing aspects relevant to a facilities management approach to climate change in a commercial setting.

3.4 Quantitative study: Questionnaire survey

The qualitative study had identified influential factors and aspects (mentioned in Chapter 5) which were important in forwarding the dialogue for a climate change adaptive facilities management strategy in a commercial setting. To ascertain the presence of these factors in not only the participating organisation but also in the wider facilities management population, a questionnaire survey was undertaken.

A questionnaire survey method was chosen due to constraints on resources available to the research study. Also, the purpose of the survey was not to establish any grounded theory; instead it was used to confirm results obtained from the qualitative study (as mentioned in the mixed-method approach outlined above).

Oppenheim (1992) suggests two basic type of questionnaire survey design: 'descriptive' and 'analytical'. The descriptive design generates basic counts of certain characteristics (as in, for instance, census or public-opinion polls) while the analytical survey design looks for differences in the representative groups or relationships between variables. This study adopts an analytical survey design as it seeks to find out the relationships between the actions taken by facilities managers and related aspects.

3.4.1 Questionnaire survey design method

On the basis of the conclusions made through the qualitative study, the questionnaire survey was designed keeping in mind three key questions:

- What are the facilities manager's perceptions of climate change mitigation and adaptation?
- What action has been taken by the facilities manager for climate change adaptation and mitigation (and are these actions strategic or operational)?
- What aspects affect their adaptation and mitigation actions?

These questions determined the variables to be examined. As Oppenheim (1992) described, these can be divided into experimental, dependent and uncontrolled variables. The overall design of the survey was derived from the strategy put forward by Oppenheim (1992), as shown in Table 1.

Table 1: Strategy for survey design (Source: Oppenheim 1992)

	Little known	**Well-researched domain**
No control over events	Cross-sectional designs, natural experiments, panel studies.	Factorial design, multivariate analysis including multiple regressions.
Power to control events	Planned prospective follow-up with control sample.	Before–and-after design (matched groups), effects and intervention studies.

In spite of best efforts to formulate an appropriate questionnaire, the researcher did not have control over the situation in which the questions would be answered by the respondents. In order to overcome this obstacle, a factorial design was adopted whereby the result of correlation amongst the questionnaire variables and logistic regression would together help substantiate the findings from the qualitative study. The questionnaire was divided into five sections (or modules), each dealing with a specific topic. The questions followed a funnelling approach whereby each section opened with a generalised question and led on to more specific and attitudinal questions towards the end of the survey. The questionnaire used a mix of open, closed and ordinal-scale questions, making it easy for the participants to navigate.

The survey thus designed was sent to all British Institute of Facilities Management (BIFM) members across the United Kingdom. It should be noted that although the study wanted to find the private-sector FM perception and action about climate change, it was not possible to consider a sample only consisting of private organisations as it was found difficult to get in touch with facilities managers, particularly in large private organisations. Thus the BIFM member's online database was considered as a sample population for the questionnaire and a web-based questionnaire was constructed. Further explanation on the choice of the BIFM database as a targeted sample population and the rationale for a web-based questionnaire is provided in Chapter 6 (section 6.1).

The questionnaire was designed using SNAP software for questionnaire design and analysis. Couper (2008) describes a web-based survey in terms of two types of tasks, the first of which deals with answering the questions while the second addresses the facilitation of navigation through the survey. Couper (2008) further suggests that the user should be able to complete the primary task but at the same time the secondary task should be available when required. Emphasis is also made on the legibility and distinction between instruction and questions through colour coding. In order to fulfil these presentation criteria, the questionnaire had included a balance of secondary tasks with distinctively colour-coded instruction and questions.

Before making the survey available for use by the chosen sample, a pilot questionnaire was distributed within a group of colleagues known to the researcher. This was to ensure the presentation criteria required for a web-based survey. The pilot survey was carried out to ascertain the appropriateness of the questions asked (i.e., whether the questions generated answers which could be used for further analysis), to find out whether a likely response rate would be obtained that was sufficient to make validated claims, and to avoid misinterpretation of any question. On successful completion of the pilot, a revised final survey was sent out as individual e-mails to 4,827 BIFM members, resulting in 479 responses representing a 10.8% response rate.

3.4.2 Analysis

A workable hypothesis and variables were set for the questionnaire survey, A table representing the relationships amongst the variables and analysis to confirm or reject the hypothesis is presented in Chapter 6

The online responses of the questionnaire were imported through the SNAP questionnaire survey software. In order to perform an in-depth analysis the use of the statistical package SPSS (Statistical Package for Social Science) was deemed necessary as a result of which, the following data preparation was undertaken. The overall process of data preparation and analysis is one adopted from Oppenheim (1992) and Pallant (2005), including following stages:

- **Preparing a code book –** In order to analyse the data in a statistical package it is necessary to convert the data obtained from the survey into a numeric form which can be interpreted by the statistical package. This process of converting the data obtained from the survey into set of variables and assigning numeric values to the answers obtained is called 'coding'. The data obtained from the questionnaire was coded using a simple numerical method **–** for example, the nominal data was coded 1= public sector, 2= private sector etc.; and the 'yes' and 'no' and 'don't know' answers were coded 2, 1 and 0 respectively. A codebook was formulated to record the coded items and any further changes made to the coding and their respective variables.

- **Creating a database –** For generating a SPSS database the responses gathered through the SNAP software was first exported to EXCEL and then to SPSS to generate a database. The variables were assigned names and definitions within SPSS.

- **Screening the database –** This stage involves checking the SPSS database for any possible errors and converting the coding as per the requirements of SPSS. (For instance, the ordinal scale (e.g. 1= strongly agree and 5= strongly disagree) used in the original questionnaire was reversed where required to make it easier to calculate a total score on some of the scales used and also to avoid any confusion which could occur while performing the correlation tests.

- **Treating missing values –** The missing values were not coded into the variables as it was decided to eliminate those cases with missing values while carrying out statistical tests.

- **Preliminary analysis –** For the purpose of the preliminary analysis, a basic frequency test on the nominal data and the calculation of mean, median (average score) and standard deviation (distance between two data points) for ordinal data was carried out, which was found to be within a satisfactory range. The distribution tests carried out to gain an insight in the nature of the data received revealed that a majority of the data did not achieve normal distribution, which offered two options for further analysis: (a) Transformation of data to be able to carry out a factor analysis suggesting a cause-and-effect model, followed by the positive correlation tests results or (b) Use of non-parametric tests , which would restrict analysis to establishing the relationship model on the basis of the correlation tests.. It was decided to adopt the latter option, as this would represent a more accurate representation of data gathered.

- **The analysis plan –** This consisted of three components: calculating basic frequencies, generating associations amongst variables (correlations) and logistic regression. The basic frequency was calculated for general parameters, such as responses from public and private sectors, and also for the various FM posts and the size of the organisation (e.g. multinational or SME). For ordinal data the frequency generated was in the form of mean, median and the standard deviation. The correlations were calculated using the Spearman's and chi-squared goodness-of-fit tests. The correlations confirmed the associations highlighted in the qualitative study and presented their strength in quantitative form. The logistic regression model was worked out for identifying the interrelation of variables responsible for mitigation approaches, and adaptation process as observed in the participatory study.

3.4.3 Theoretical limitation

The theoretical limitations to regression analysis are:

- Inference of a causal relationship between the associated variables; and
- The selection of dependent and independent variables.

On the issue of inference of a causal relationship, it has been argued that a high correlation should be expected because of shared variability amongst the variables and not due to the causal relationship between them.. The shared variability can occur as a result of the influence of many other variables that are not measured. On the other hand, the concerns are observed pertaining to the selection of the subset of dependent and independent variables for regression, such that the highest multiple correlation and significant variable with predictive power are included.

As a remedy to these arguments, Tabachnic and Fidell (1983) suggested that, statistics should be used to quantify the relationships, which are initially supported through logical and experimental exploitations. This was done in the present study on the basis of observation made through the participatory study and the literature review.

3.4.4 Practical issues

The practical issues on regression analysis are related to (a) the number of cases and variables included in the analysis, (b) so-called 'outliers' and (c) multicollinearity and normality. The issue of normality did not affect the analysis as the chosen standard logistic regression method does not follow the assumption concerning the distribution of the score for the predictors (Pallant 2005). Although there is no rule of thumb for determining the sample size for logistic regression, Harrell (2001) suggests more than 10 cases per predictor variable in logistical regression and this was adhered to in the logistic analysis. The sensitivity to multicollinearity was resolved by undertaking collinearity tests in SPSS, where the tolerance values were checked. As per Pallant (2005) tolerances that are lower than 0.1 are an indication of multicollinearity. Since no tolerance values in the analysis were found to be less than 0.1, it was concluded that no multicollinearity existed between independent variables.

3.4.5 Validity / reliability of the survey

Validity in a questionnaire survey deals with preposition of the reliability, i.e. the variable in question should both be externally and internally reliable (Bryman and Cramer 1994). External reliability ensures the consistency of the measurement scale over a reasonable period of time. External validity is ensured through test–retest reliability whereby the survey is administered in different time frames. Since it was not possible for the present survey to be subject to such an exercise, the consistency of responses of the pilot survey and the main survey were taken as fulfilling the external reliability of the survey. The internal reliability of the survey scale deals with multiple-scale questions where different items within the scale are set to measure one underlying construct. The only such scale used in the survey was the 'new environmental paradigm' scale, which is an established reliability scale devised by Dunlap et al (2000).

The validity of a questionnaire can be ensured through checking for face validity, , construct validity and convergent validity. The questionnaire survey was checked for all three validities.

Face validity is the most common validity check, whereby it is ensured that the content of the question addresses the underlying concept to be checked. For example, within the present survey the questions dealing with enquiry about mitigation actions were classified in a separate module dealing only with mitigation and enquired specifically about the measures undertaken, thus directly addressing the underlying concept of only the mitigation approach used within the organisation.

The construct validity check is undertaken by hypothesising from a theory or concept and investigating the deduction of the hypothesis by examining the relationship between two set variables. The present study had derived the concepts from the qualitative study and had set the hypothesis based on these concepts. For instance, it was conceptualised from the qualitative study that the approach to adaptation of the built assets will be operational in nature, unlike mitigation (which will be strategic in nature). This was checked through the questionnaire survey by inquiring about the adaptation and mitigation action taken and relating it to the overall approach taken by the organisation.

Convergent validity is established by reaching a singular result through different measures. These measures could be taken from one or more methods. For instance, the present study establishes convergence of the results from two different methods – i.e. converging findings from the participatory study and the questionnaire survey where the observations made during the participatory study are examined and enlarged upon through the questionnaire survey.

3.5 Chapter summary

This chapter has presented the philosophical assumption and the research methodology adopted in the research project. It outlines the mixed-method approach undertaken, whereby qualitative (participative study) and quantitative (questionnaire survey) methods are combined towards fulfilment of the research questions. Each of these methods, as well as the data analysis and validity criteria, is addressed.

The qualitative study (interviews) has established the contextual factors, which influence the formulation of the climate-adaptive facilities management strategy within a commercial context. Participatory observation outlined the important aspects observed while implementing the UKCIP decision-making framework and the UKCIP02 climate change projection data with a team of facilities managers; the built-asset exposure assessment and resulting adaptation process were noted. The validation of these findings was achieved through an online questionnaire survey administered within the wider community of the British Institute of Facilities Managers (BIFM).

The following chapters will explain the interviews and participatory observation study results, followed by chapters on the results of the questionnaire survey and their related statistical analysis. The remainder of the thesis will discuss the conclusions and future research agenda arising from the study.

Chapter 4: The UKCIP framework and the participating organisation's FM team

This chapter presents the participating organisation and contextual factors within which the strategic and operational aspects of the organisation are understood. The study was undertaken between April 2006 to April 2007.

The overall organisational context is discussed in Section 4.1 by drawing on the organisation's historical approach towards sustainability and climate change, noting the shift to present-day strategies and its intention to be involved in the present research study. The organisation's facilities and operational strategies are outlined in Section 4.2 by including a description of its operational structure and the actions taken to address CO_2 reduction (mitigation) and the physical impacts of climate change (e.g. flooding and overheating responses towards adaptation). The internal and external factors determining strategic response, attitude, perception and action are addressed in Sections 4.3 and 4.4. This includes external factors determining organisational attitudes and strategic responses towards climate change. Facilities team perceptions and actions for climate change, influenced by the internal factors such as financial viability and resource availability, are presented. The staff knowledge, skills and internal capacity to address climate change impacts are mentioned in Section 4.5. The summary in Section 4.6 outlines the key aspects of the chapter.

The participation in informal discussion and interviews is quoted, where necessary, with reference to date and type of discussion – i.e., informal discussion (ID) and interview participation (IP). The identity of the participant is not disclosed.

4.1 Organisation context

The participatory organisation is a commercial banking organisation with much of its operational activity and built assets in the United Kingdom. The total built-asset portfolio of the organisation was valued in 2003–05 at £370 billion, but there has been an increase in value since 2005 through the acquisition of new businesses alone.

The organisation's historical approach to the environmental and sustainability debate has been studied to establish the overall context. The inclusion of climate change issues at strategic level and the present shift to address the issue in greater detail is noted so as to gather the complete picture of the organisational approach to climate change.

4.1.1 The organisation's historical approach to environmental issues

The historical approach of the organisation was determined through a study of its strategic and environment policy documentation supported by informal discussion with the organisation's managerial staff. The period covered for this enquiry spans from 1992 to 2003. During this period, and being a service sector business, the organisation did not counter much of the environmental impacts other than its office base energy use, waste and travel.

As a result of the Rio summit and the UK Government's sustainable policy, the business had formulated an environmental policy in 1992–93, which has been periodically updated. The environment policy included an energy management programme in 1988, saving the organisation £1 million per annum in energy costs. The objective of the policy was that of "stewardship and responsibility, compliance, environmental risk pollution prevention, and product and business development". Environmental reporting has been included in the corporate responsibility report since 2002–03, which followed the global reporting guidelines and AA1000 Accountability Principles Standard (AA1000 APS) for reporting. The organisation has been a signatory to UNEP (the United Nations Environment Programme) and an international commerce charter for sustainable development; it has also followed an internal environmental management system based on ISO 14000.

Subsequent to this, the organisation had been awarded accreditation for achievements in energy efficiency by the Institute for Energy and had been involved in procuring renewable energy contracts since 2003 in its various branches across the UK. It had set the target of a 5% reduction in its CO_2 emissions in 2005, down to the 2000 level. In 2005 a new target was set of a further 5% reduction from the 2005 baseline for the period to 2010. This was noted as the initial strategic move towards reducing CO_2 emissions as gathered from the response:

> ***"We had to address the CO_2 agenda in our offices … energy use was becoming increasingly important." (April 2006-ID)***

The responsibility for policy planning lay with the executive management committee, while implementation has been a responsibility of all the managers as evident from the quote below

"Our managerial staff is very much responsive to the environmental aspects of the company and do accomplish almost all the targeted results." (April 06-ID)

The historical response of the organisation to wider international and national debate on energy efficiency and business environmental impacts was noted by the research team to be reasonable and reactive in nature.

The business has been measuring and reporting the environmental impacts consistently in its corporate responsibility report since 2002, which increases transparency and guides further action for overall impact reduction specifically in energy efficiency. The majority of business action has been towards minimising office waste and gaining high standards of energy efficiency and management.

Overall, the environmental policy and initiatives indicated an aware organisation that, while addressing the impacts and giving attention to the environmental debate, has regarded business reputation and business development as key environmental policy objectives.

Compared with other similar organisations in the sector (primarily the other three large banking entities within the UK), the organisation participating in this study has placed itself at moderate level with regard to its environmental policy formation, action and reporting. As a result of this, and in spite of being considerate towards environmental issues, the organisation remains a laggard rather than in the forefront. This results in reactive and moderate emissions reduction targets which are aligned with overall business needs, reputation and development.

4.1.2 The organisation's Approach from 2005 to 2009

By the end of 2003 the organisation had developed a large property portfolio through business development and acquiring new businesses in the sector. This led to research involvement for innovative processes for built-asset maintenance and management. The present research was part of this drive, initiated in 2005 in participation with the University of Greenwich, for addressing climate change impacts on the organisation's built-asset portfolio and its future capacity to contain the business operations.

From 2005 and during the extended research period, a shift in strategic and targeted action for climate change was observed – partly in response to the increasing climate change debate and related planned legislation, and partly due to business loss occurring as a result of climate-related impacts (e.g. flooding). The following responses are relevant:

> ***“We are holding on right now…with present scenario (regulation) but a lot is going to change for our buildings with Part L and EU directive.” (June 2006-ID)***

> ***“We have just been hit by a heavy flood…and the loss has made us to look at this extreme weather issue. …Don’t know if it is due to [climate] change.” (July 2006-ID)***

The organisation has been participatory to the carbon disclosure project and CDP 3 (2005). CDP 4 (2006) has been found to be more comprehensive, leading to a reduction of 78,000 tonnes of CO_2 reported by the organisation in 2006 from a 2000 baseline, and the inclusion of an improved emission target of 20% per employee by 2011. The partnership with the Carbon Trust and the Energy Saving Trust seems to have improved the emission reduction awareness and clarified the impact of government policy.

The CO_2 reduction had been achieved by implementing energy and building management initiatives which have been included in the facilities and operations strategy, but the issue of extreme-event-induced losses has not been addressed in totality and was considered to be a risk to the extended built assets of the organisation.

4.2 Facilities management and operational (FM&O) strategy

The facilities management strategy of the organisation (see Figure 9) is planned based on objectives of cost, service delivery and customers and staff satisfaction for a time span of every three years. From this, critical success factors (CSFs) are set within the annual strategy, and targets for achieving the CSFs are derived to be fulfilled thorough maintenance processes. These are monitored on monthly basis. The strategy takes account of services, new and existing project work, supplier management, space management and strategic performance.

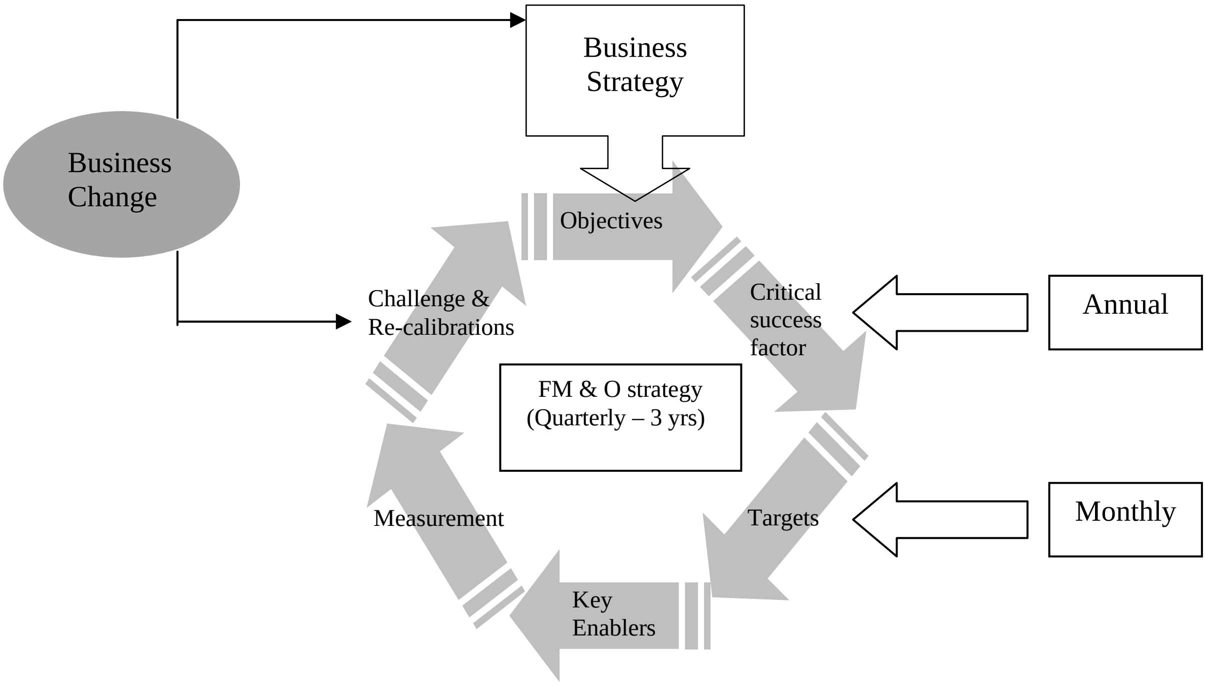


Figure 9: Organisational FM&O strategy framework

The facilities and operational strategy integrates targets set in the organisation's sustainability strategy. For achievement of these targets for emission reduction, energy efficiency and water consumption, the FM and logistics department was restructured in 2003 and given responsibility for energy management and utility strategy.

The organisation operates across the United Kingdom and the Republic of Ireland and at the time of the organisation's involvement in this research had six regional sectors each headed by a senior FM who reported to the strategic FM member at board level. A junior FM team member in turn assisted the senior FM at each regional level. The in-house and externally contracted technical support team supported the office functions.

4.2.1 Measures taken and strategic actions

As a result of increased external debate and regulations, the organisation had established executive-led subgroups to focus on specific issues of product and service innovation, climate risk, employee engagement and the organisation's carbon footprint. This has led to increased engagement of facilities and operational management staff in climate change mitigation measures.

At the time of the study, the facilities and operational strategy included the delivery of agreed reduction targets across its property portfolio, achieving environmental management certification (ISO 14000) across key sites and energy performance certification for 50% of its entire built-asset portfolio. A senior FM team member was given the responsibility of achieving energy efficiency targets and related activities within each regional sector of the organisation.

The prime strategy adopted for achieving the targeted emissions reductions was to procure energy via a renewable-energy supplier contract. It was deduced from the following participants responses that this was an easily implemented measure as the increasing property portfolio under various acquisitions had different management regimes and it was not always possible to implement other technical energy efficiency measures.

> ***"This is the most effective way to reduce our emissions considering the complexity of management of new buildings we are acquiring now." (Aug 2006-IP)***
>
> ***"In 2005 UK (and Ireland) Energy emissions per £ million of income was 8.5 tonnes of CO_2 compared to 14.5 tonnes in 2004 and the renewable electricity consumed, measured as a proportion of total electricity, was 66.9% (28.5 % in 2004, 14% in 2003." (CDP response 2006)***

This strategy was given priority above all other measures for emissions reduction even in later years (2005 to 2009), with 92% of total energy being procured from renewable energy suppliers in 2009.

In order to engage the business in ongoing climate change and policy debate, the organisation takes part in the environmental steering group of the Confederation of British Industry (CBI) and is an active member of the UK steering group of the UN Global Compact and the UNEP programme for financial institutes.

4.2.2 Technical measures

Since 2005 to 2007, the organisation has invested £55 million in programmes for achieving energy efficiency across its property portfolio and has since achieved ISO 14000 certification and Energy Performance Certificates across various sites.

The investment programme includes the installation of a wide selection of improvement options such as enhanced building controls, additional metering, low-energy consumable (DALI) lighting, low-emission high-efficiency boilers, plant efficiency improvements, wind power generation (on a small scale) and enhanced insulation and glazing initiatives for solar reduction and heat recovery (CDP 2007). The new and refurbishment projects attempt to include heat reclamation, enhanced building management systems, internal lighting control systems and centralised utility metering technology as minimum, in addition to other fabric and/or services improvement options. In 2005–06 these improvements were undertaken in 10 major sites, and another 150 sites with 15 high-rise buildings were being surveyed for implementing additional energy-efficiency measures. (Source: Participatory organisation's workplace strategy and CDP response.)

4.2.3 Behavioural measures

As a part of encouraging behavioural change, 'switch off' reminders were set on every PC and on lighting controls. Also, employees were encouraged to use video- and audio-conferencing and rail travel links to reduce per employee emissions. An in-house sustainability management team and an internet portal for providing guidance on reducing the organisational and personal carbon footprint for staff were launched in June 2006.

Although instigating behavioural change for energy efficiency and CO_2 reduction has shown reasonable results, a significant change is noted in waste reduction amongst employees, with increased employee demand for recycling facilities in and around office locations – a demand that was fulfilled in July 2006.

4.2.4 Section summary

The historical approaches of climate change of the organisation had been reasonable, keeping in mind the reputational and legal aspects. It was observed that the organisation, through a mix of strategic and technical measures, had addressed the mitigation (CO_2 reduction) agenda. The staff's behavioural change was also attempted through information and incentive provision.

In contrast to this, the risk arising from the physical impacts of climate change on the organisation's business in general and its built assets in particular was not adequately addressed:

"We have and are doing a lot for CO_2 … but I am worried about the heavy flooding and overheating issues … and I think [whether] we believe it or not (it is due to climate change or otherwise) looking at the present routine (weather changes), we might face more of them in future." (Aug 2006-IP)

The FM team had shown concern for such impacts as there were many key deliverables within the FM&O strategy which were likely to get affected as a result of physical impacts of climate change – for example:

- Achieving 100% of operational risk minimisation for critical buildings;
- Minimising operational downtime after a major event;
- Reducing the number of building failures; and
- Management of poor-performance buildings.

In order to achieve the aforementioned deliverables and reduce the physical impacts of climate change, the present research study was undertaken in collaboration with the selective FM&O team.

4.3 External factors affecting the organisation's strategic response

The external factors influencing the participating organisation's strategic response towards climate change are discussed here, which adapts much from the literature review outlined earlier on possible organisational strategic approaches to climate change. The external factors identified that were found to influence the strategic response are legislation, corporate social responsibility (stakeholder relationships) and finance.

4.3.1 Legislation

Much of the participating organisation's response to climate change was driven by government legislation. Operational measures were taken to fulfil the legislative requirements in the most cost-effective way. This was evident from the informal discussions held:

"We have to take care of the minimum required by the government… the management is only concern with meeting the requirement by spending a bare minimum." (Oct 2006-ID)

Legislation such as the climate change levy had already started to impact building energy use, and the strategic cost-effective response to this was to procure renewable energy contracts across the entire portfolio.

"This was the best option, I think, that was available to us considering the way the [climate change] levy has been structured…We have a large portfolio and rolling individual measures would take a long time." (Oct 2006- ID)

There was also a view presented that without legislative drive it would be very difficult for individual staff members to implement CO_2 reduction measures and that the senior management agreement to any action will only come through legislative requirements:

"We could have managed these [renewable contracts] a bit earlier but I think the general feel is that if we are not really required to do it then why worry too much about it?"(Oct 2006-ID)

"I think legislation is the only way to move the commercial sector. Like everyone, we [the commercial sector] do something only if there is something in it for us or we are plainly required to do so." (Oct 2006-IP)

There remained a strong opinion amongst the senior management that they will see increased legislation for CO_2 reduction. At the time of the study, Part L of the national building regulations, energy performance certificates and the WEEE directive were going to be implemented in the near future:

"We are already seeing a big wave of compliance (Part L and EPC) and I won't be surprised if in the next 5–10 years we will be required by law to be carbon neutral." (Oct 2006-IP)

Furthermore, there was a strong perception in existence suggesting that the increased legislation will alter operational and built-asset management:

"We will now see a fundamental change in how we operate our buildings. It would not be business as usual any more …especially with energy use and refurbishment." (OCT 2006-IP)

In summary, existing and future compliance has led to a perception formulation that any action for CO_2 reduction will have its driver from legislation, that these legislative drivers will increase in the future with more stringent reduction targets requirements, and the commercial sector will need to alter the way it manages its buildings.

Although legislation was a prime driver for emissions reduction, the same could not be said for adaptation to the physical impact of extreme weather. At the time of the study, improving resilience against physical climate change impact was low priority in the organisation because of a lack of any drive and support from management. In the absence of this, the reason to take any action was solely emphasised as the risk of financial loss faced by the organisation due to an extreme event. It was evident from the discussions that, just as in the case of CO_2 reductions, a strong driver was required (in addition to imminent financial loss) to adapt the built-assets and business operations to the increased extreme weather events being experienced. There also remained disbelief about the occurrence of extreme weather events in relation to climate change. Thus:

"We are achieving the reduction [in CO_2 targeted emissions] but loss due to the actual extreme effects is also an important aspect. [Scientists] are saying that we can't connect them both [climate change and extreme weather] … but the fact is that, CO_2 or no CO_2, we will bear the full brunt of this." (Oct 2006-ID)

"Why is no one specifying a minimum [regulation] for flood protection for our coastal properties? … We are talking recurring losses here." (Nov 2006-ID)

"Someone has to drive this [making buildings resilient to extreme events] from the top. We can see it on the ground and [climatic] conditions are different than before. …Something needs to be done about the [built] stock." (Nov 2006-ID)

"We can work with insurance till so long. If [the occurrence of extreme weather events] continues, I think even [the insurance companies] will put their foot down at some point."(Nov 2006-ID)

Loss occurring due to an extreme event had led to a perception of physical climate change impacts as a potential risk amongst the operational maintenance team. Even so, uncertainty prevailed about the accuracy and spatially detailed climate change projection and especially with regard to extreme weather events. In this case the team looked for a structured way to assess the risk and derive options to deal with such impacts within the remit of available climate change data. This study thus formed a part of this intention to develop an FM&O strategy, which integrates increased built-asset portfolio resilience.

4.3.2 Corporate social responsibility (stakeholder relationships)

In the competitive market scenario, stakeholder relationships (so as to be seen as doing the right thing) have been key for every commercial organisation. Corporate social responsibility (CSR) is seen as a vital tool to inform various stakeholders about environmental and financial success. Much of the action on the ground within the participatory organisation was deemed necessary towards the fulfilment of the strategic targets to be published in the CSR annual report:

> ***"[Whether] 5% or 10%, we need to be seen as doing the right stuff. We can't afford to miss targets." (Nov 2006-IP)***

The organisation at a later stage had been participatory to the carbon disclosure project, FTSE4Good and the Dow Jones sustainability index. These had given added importance to the achievement of targets and performance above the minimum action required. This was seen as a key to organisational reputation and also to staff perception of being associated with climate-aware and active business:

> ***"We need to keep our records in order for all [CDP] reporting. In a way it is good as it gives us an incentive to move further in our environmental agenda." (Nov 2006-ID)***

4.3.3 Finance

The financial issues affecting the participating organisation's strategic response dealt with both the long-term viability of any strategic decision (business sense) and investment in new technology where there is a reasonable payback period. Indeed, a prevailing view amongst the senior management of the organisation for taking any CO_2 reduction measure was that it should make business sense and be financially viable:

"There is no point in investing millions in something that will give us minimum returns on energy bills. The budget constraint does not allow it." (Nov 2006-ID)

"Spending on any measure has to be in accordance with overall business expansion plan … otherwise there is no point to any of it." (Nov 2006-ID)

There was a strong view that any investment made should be over a long period of time and should ensure adequate returns for investment made (for example by phasing out inefficient air chillier to avoid one big outgoing expense). Also, minor repair and adjustment over installing a complete new system was preferred in accordance with achievable efficiency.

The other important financial barrier was that of investment in new technology and the risk associated with the payback:

"Even today microgen tech [micro generation technology] like solar is expensive and has operational and maintenance issues. …We can probably install them across all the buildings but justifying the upfront cost and payback would demand effort." (Nov 2006-IP)

"There is no issue with the capital cost but it should be at least a safe bet." (Nov 2006-IP)

Considering these barriers, the staff members interviewed were in agreement that procuring renewable energy was the best option to reduce the emissions from the organisation's increasing property portfolio at the lowest cost possible, with guaranteed returns through a reduction in climate change levy charges.

The view in terms of making buildings resilient to physical impacts of climate change differed from the aforementioned opinion. A perception of such impacts being a risk to the built-asset stock already prevailed in FM&O staff. Thus it was a common consensus that this risk should be mitigated in the key sites at any cost, while a 'wait and watch' approach should be applied to the rest of the stock. The reason for this view was once again the financial constraints on the overall maintenance spend and uncertainty associated with future climate change projections:

"We can go out and do work on fabric and [building] services provided we are certain [of reoccurring extreme events] and can make a case." (Nov 2006-ID)

It was also observed that making a financial case to carry out major refurbishment work for making the building resilient was difficult for the maintenance management staff unless recurring events had caused substantial damage to the site and it is of business importance. The staff called on unstructured assessment, lack of substantial evidence and support, and constraints on time and other resources required for carrying out such processes as reasons for failing to make a case to senior management:

"The problem is, however well you know the ground situation …it takes a long time to put this on paper in a structured manner which can win required support from the guys on top." (Nov 2006-ID)

"It takes long to convince the guys on top…it's easier to deal with such situations as and when they occur." (Nov 2006-ID)

Although a common consensus existed amongst those interviewed for long-term planned maintenance and refurbishment, especially considering the future adaptation of the built portfolio against physical climate change impacts, there were very few attempts made within the organisation to achieve this.

4.4 Strategic priorities, internal processes and FM&O staff perception

In addition to the external factors identified influencing the participating organisation's strategic response, there were many internal processes, staff perceptions and strategic priorities which were noted to be decisive in action for CO_2 reduction and adaptation of the building stock. The following sections outline some of the internal processes, barriers and staff perceptions observed during the study period.

4.4.1 Strategic priorities

In terms of built-asset strategies the prime objective of the organisation's FM&O strategy was, first, cost effectiveness – to achieve minimum maintenance and refurbishment downtime and space efficiency in order to reduce the overall £/m^2 maintenance cost. Secondly, it was to achieve a reduction of accidents and complaints; thirdly, the strategy needed to be regulation–compliant; and last but not the least it needed to achieve excellent service delivery for customers.

Although the sustainability and environmental targets had, by the time of the study, been integrated into the FM&O strategy, they have been competing with the aforementioned priorities and objectives. For example, the cost imperative meant that short-term technical fixes were adopted in the first instance instead of investing in long-term fixes. The cost consideration had also been one of the decisive factors for participation in the present study because the financial loss sustained as a result of extreme weather events occurring in key organisational sites had been perceived to be increasing:

> ***"We now have a big portfolio, and energy requirement is higher. …The cost implication of this will be enormous for us if the tax and energy prices keep rising." (Dec 2006-IP)***

> ***"Our main priority is to reduce cost and achieve the targets within the budget, be it service delivery or CO_2 reduction." (Dec 2006-IP)***

In recent years, waste reduction, recycling and CO_2 reduction have gained if not a higher priority then an equal priority to other goals and objectives with the FM&O team, owing to many regulatory and external factors.

4.4.2 Internal procedural aspects

During the study period, internal procedural aspects were brought forward which had impacted the agenda for CO_2 reduction and the adaptation of built assets. Prime amongst those procedures were management integration, lack of awareness, a bottom-up approach, financial performance and a focus on short-term benefits.

The bottom-up approach and lack of awareness amongst staff at multiple sites were noted to be significant aspects prior to the study period as many ad-hoc measures had been undertaken at various properties but communication of their success and further strategic support had been difficult to achieve for the facilities team. This communication gap and the prioritisation of short-term gain was seen as a major obstruction to achieving integrated strategic planning towards addressing issues surrounding CO_2 reduction and long-term built-asset adaptation:

"I can account for [take reduction measures for] CO_2 reduction at my site because I have control over certain things…but to achieve this across all sites you need to have a coherent and continuous dialogue." (Dec 2006-IP)

"I don't think anyone knows exactly how are we going to [be resilient against extreme weather events]…every one of us [in the site's FM team] have some idea or the other but there is no definite structure to the whole thing." (Dec 2006-ID)

Some of these aspects had been addressed at later years and during the study period by establishing a senior-executive-led group for addressing the climate change agenda, while individual site managers were given the critical success factor of fulfilling their targets.

In the recent period the internal procedures were beginning to get aligned to long-term CO_2 reduction due to the formulation of specific mitigation targets, but the adaptation of business operations and built assets to physical climate change impacts lacked any specific targets and top-level agreement. This led to an ad-hoc approach towards making individual built assets resilient to future climate change impacts.

4.4.3 Perception and attitudes of FM

With regard to the action for future climate change and its impact on the business operations and built assets, the FM team had prevailing perceptions and attitudes. These were based on the existing stock condition and ownership patterns, data availability both of built-asset and climate change projections, possible long- and short-term measures (with strategic alignment), belief in actual human-induced climate change, and the level of action the organisation can undertake. These aspects are discussed below.

Also, being a commercial organisation meant that much of the staff's attitude showed extrinsic value consideration.

4.4.4 Existing stock condition, ownership patterns

The organisation in 2005/06 retained a total of 2,963 commercially operating properties out of which 777 properties (26.2%) were multi-occupancy or were retained on a lease. Also, within the rest of the approximately 80% of stock almost 5% were heritage built assets and a further 10–

15% of stock was old or presented barriers in carrying out major refurbishment work. The FM team was of an opinion that it would be very difficult to carry out any alteration works on these property stocks due to varying occupancy patterns, heritage building regulations and age of stock:

> ***"We can think in terms of the future and plan as much as we like but we won't be able to do anything to, I think, almost half of our stock – the opportunity is limited." (Dec 2006-IP)***

The team's attitude about the intervention to the rest of the stock was that any alteration carried out couldn't be on a major scale (e.g. major façade or fabric alterations, or replacing major structural or building components). This was due to an opinion that such measures will be more disruptive to existing service delivery to users than smaller works, and further on it may not be financially viable:

> ***"I think we should take up small-scale works for the key buildings first … the budget will not allow the major works." (Dec 2006-IP)***

The issue of ownership was also one which was put forward as a concern by the team. Since the organisation had acquired many smaller businesses within the United Kingdom, its property portfolio now included varied ownership patterns and disintegrated property management practices. Although in time the newly acquired portfolio would have its management amalgamated with present practice, at the time of the study this was perceived as barrier to putting forward a coherent plan:

> ***"The new properties are taking time to be set up as per our own stock." (Dec 2006-IP)***

4.4.5 Data availability

Before the introduction to the UKCIP framework, the organisation's FM team expressed concern about data availability on any past damage that had occurred due to climate-related events from which a damage scenario could be constructed and, secondly, on their understating of the availability of climate change projections and data.

There was much data available on energy use in buildings and transportation, but very little was known about the past damage that had occurred due to climate-related events, such as heavy rains or storms. This was important to know because such events were projected to be increasing in the future due to climate change, and damage that had occurred in the past was the only reference to guide future actions.

The unavailability of such damage data was due to the acquisition and disposal of new and old built assets and unkempt record-keeping related to that, especially in cases of damage scenarios:

> ***"If I had past data for my property, it would be much easier for me to conduct future enquiries, I guess." (Dec 2006-ID)***

In addition to this, the FM team showed concern about understanding the UKCIP02 projection data. Since the team did not have access to climate data on a regular basis within their work arena, it was difficult to gather an overall understanding of such data. Also, the data produced by UKCIP02 was on the basis of long time series stretching to 2020, 2050 and 2080 (each a 30-year time series), which the team found to be unhelpful for the short 5–10-year spans they were dealing with for business changes and the FM strategy cycle.

4.4.6 Belief in human induced climate change

Before the study period, the belief in human-induced climate change was not found to be prominent in the team. This was evident while talking with the team on the subject of climate change and its impacts of the organisation's built assets. There was a general belief that the environment should be taken care of and the activities should be sustainable, but eliciting all the changes due to CO_2 increase was not well grounded in the FM team's thinking:

> ***"You say it is only now that we are experiencing this weather but I say we have had many cycles in the life of Earth, with ice ages and heat waves. What about them?" (Jan 2007-ID).***

> ***"We have all joined this bandwagon of CO_2 increase. I bet 10 more years and we will join the other bandwagon with some other element or gas…It is all very much political." (Jan 2007-IP)***

It was a common perception that some changes are occurring but the reason for them being human-induced or a CO_2-increase-based change was not believed to be completely agreed on by the scientists. Also, there were many misinterpretations occurring between ‘weather’ and ‘climate’ because use of these terms was very easily misplaced – both weather and climate were regarded as one and same. There was very less concern, at the time of the study, for long-term changes than for something that would happen in the coming three or four years.

4.4.7 Organisational role in taking action

There was also a common perception in existence that not much can be achieved, in terms both of mitigation and of adaptation, by private-sector action alone. Instead, the overall government action could be supported by the private sector:

> ***“They [the Government] can’t expect us to bear the maximum brunt just because we make more profit. There is a limit to how far we can take some action.” (Jan 2007-IP)***

> ***“We can do something to our [drainage] services but can’t replace the old system [of local-level drainage] if it continues to rain heavily every winter.” (Jan 2007-ID)***

Where the organisation did not have past data on climate related events in a specific region, it had expected the local authorities to have a register for such events, which was not always possible to obtain easily as the questionnaire with the local authority later in the research study will show.

In such a scenario the team was of an opinion that the organisation could do only so much to reduce its impact on the environment and also not get severely affected by it in return if climate change projections were not realised:

> ***“Our aim is to survive and survive successfully in the midst of all the regulation and the [extreme event] impacts.”(Jan 2007-ID)***

4.5 Knowledge skills and resource availability to the FM team

The knowledge and skills of FM team members, in addition to other internal issues, was a topic that was equally important in managing the climate change mitigation and adaptation agenda within the organisation. These in particular dealt with knowledge of the physical future impacts of climate change on built assets and the technical solutions for adaptation.

4.5.1 Knowledge and skills

The existing knowledge of team members regarding mitigation and CO_2 reduction were regarded as adequate given that many attempts were made by the team to look for additional information on how to implement technical fixes to reduce energy consumption. These were in the form of acquiring knowledge from external experts and institutional publications, and attending seminars and conferences on the issue.

In contrast, the knowledge on the future physical impact of climate change on organisational built assets was found to be at minimum, the likely reason for this being the lack of detailed knowledge of climate change projections and future scenarios and also that FM professional are not accustomed to work with climate/weather data on a daily basis. Thus:

> ***"There are three time [series] projections and each with a different scenario. This is very confusing for a building person like me." (Jan 2007-ID)***

Although the team was given a brief introduction on climate projection (UKCIP02), the efficient use of climate change projection data by the FM team was not grounded during the study period as FM personnel generally have minimal familiarity with such data in their daily work schedule. Also, an attempt to spread it across the rest of the staff was not seen as a priority among the team members because much of the importance was still given to CO_2 reduction measures rather than improving the built-asset resilience against climate change impacts. Thus:

> ***"A 2^oC rise in temperature or 5% rise in precipitation is relevant information but I need to know what risk it will raise for my building." (Jan 2007-ID)***

The existing skills and capacity of the FM staff were predominant in mitigation aspects, with knowledge being apparent of technical intervention such as energy-efficient lighting and SMART energy meter installation. Much of this knowledge was also found to be in area of setting renewable-energy contracts and the mixed use of renewable and non-renewable energy in various operations. Skills with regards to translating climate projections into the physical impact on built assets, as well as risk assessment techniques, were found to be lacking in the team.

In spite of some external consultation in the area of flood risk, further action was not followed because understanding and operation of flood simulation modelling for flooding scenarios and also for overheating scenarios were not thought to be within the remit of the team. The constraints were also highlighted due to internal limited capacities in terms of finance and skills to generate such data.

4.5.2 Partnership

There was a general view prevailing among the team that an external (possibly Government) partnership was required to address the area of climate change adaptation, as many of the actions and data were not easily accessible and also not within the remit of the organisation (for example before the Climate Change Act 2008):

> ***"If the [local authority] do not have required data on their territory, then it is very difficult for individual sites to have any such historical records." (Jan 2007-ID)***

> ***"In a major [extreme] event, we rely on [the local authority] to handle bigger aspects (emergency relief and temporary services)." (Jan 2007-ID)***

As a result, the final adaptation option selection from the participating organisation's FM team also included partnership working with a local authority as a potential route for improving the organisation's built-asset resilience.

4.6 Chapter summary

In summary, it could be said that climate-change-related issues have competed with other organisational priorities, namely finance and resource availability, better staff productivity, better space management, and staff retention. Table 2 lists the organisational contextual factors within which the strategic and operational aspects of the organisational action for climate change are understood.

Table 2: Organisational contextual factors influencing the action on climate change

Headline contextual factors	Subsidiary factors
External factors responsible for organisational strategic response	a) Legislation b) CSR (stakeholder relationships) c) Finance
Strategic priorities and internal processes	a) Strategic priorities – cost , target fulfilment, maintenance and refurbishment downtime b) Internal procedural aspects – management integration, lack of awareness, bottom-up approach, short-term benefit focus c) Perception of FM: * Stock condition and ownership pattern * Data availability * Belief in human induced climate change * Organisational role in taking action.
Knowledge, skills and resource availability to the FM team	a) Knowledge and skills b) Partnership

It was also noted that even where the climate change agenda took precedence, CO_2 reduction and the mitigation agenda took priority over any adaptation to the physical impacts of climate change. This prioritising was observed to be realised as a result of increasing Government legislation on mitigation and other external factors such as stakeholders' perception and market standing. On the other hand, adaptation was only made a priority as a result of the impact of an extreme event on the organisation, and the financial loss occurring as a consequence.

While addressing the issue of physical impacts of climate change, the FM&O staff's knowledge, skills, perception and other internal factors played a major part. The belief in human-induced climate change also played an important role while undertaking the implementation exercise for the UKCIP decision-making framework, as will be explained in the next chapter.

Chapter 5: UKCIP Framework stages and discussion of outcome

This chapter reports in section 5.1 on the facilities team involved and the protocol agreed for UKCIP decision-making framework implementation. Sections 5.2 to 5.4 present discussion on the outcome of the first three stages of the UKCIP framework implementation exercise, while section 5.5 summarises the overall result of the implementation. Section 5.6 presents conclusions and highlights the need for further validation of the observations.

5.1 The UKCIP framework and the terms agreed for its application

The UKCIP decision-making framework presented in Figure 10 was implemented with the FM team of the participating organisation. The team had total a total of six members: one member from strategic FM (a senior regional facilities manager), two members from the facilities managers' team and three onsite junior managers.

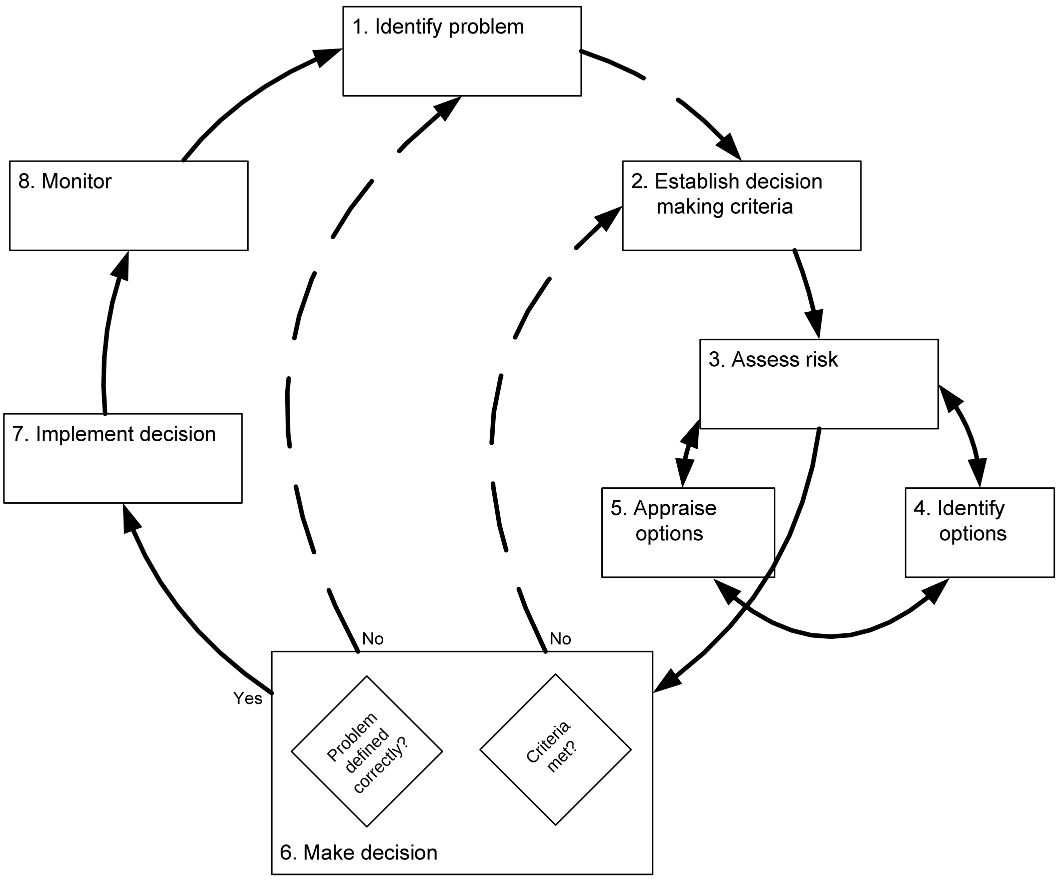


Figure 10: A framework to support good decision making in the face of climate change risk (Source: Willows and Connell 2003)

At the beginning of the UKCIP implementation exercise a protocol was set with the FM team to ensure a cohesive process. As per that protocol, the following guidelines were established:

1) The exercise would make use of UKCIP risk–uncertainty and the decision-making framework in the face of climate change (Willows and Connell 2003), along with the UKIP02 projections and scientific information.
2) The participating team members would remain the same throughout the process and this team would include senior and junior members from three regional set-ups in the organisation.
3) At the beginning of each stage, a short presentation would be given by the researcher on the importance of the stage and the questions to be answered during the stage. The method adopted for answering the questions was dependent upon a choice made by the FM team themselves. A brainstorming group exercise was to be adopted at every stage due to unfamiliarity of the subject matter to the FM team (particularly in the areas of climate change projections and a new decision-making tool).
4) The answers at the end of each stage would be recorded and distributed amongst the team for any further verification. Only after the final verification would a move to the next stage is considered.
5) Any concerns within the team would be addressed at the completion of each stage, before embarking on next stage of the framework.
6) The compilation of any documentation on the organisation's built-asset adaptation options would be within the remit of the FM team, where the researcher would put in any input only on demand from the team.
7) The documentation generated from this exercise would be the property of the participating organisation and its only use by the researcher would be for purely academic purposes while respecting anonymity.

During the implementation exercise minimum intervention was sought from the researcher. The researcher's role was to make observations while the FM team sought a practical, structured solution.

The description of each of the stages presents details of the stage, the importance of the stage, and the key questions and answers to support an understanding of the stage. Completions of the stages are provided in the Appendices to this thesis, as referred to in each stage description below. The selection of the methodology adopted by the FM team to answer the appropriate questions is also mentioned below, followed by a summary of the stage along with the researcher's observations.

5.2 UKCIP Stage 1 – Identify problem and objectives

As described in Chapter 3 and as shown in Figure 10 above, the UKCIP decision-making framework is made up of eight iterative stages. The first amongst them is 'Identify problem and objectives'.

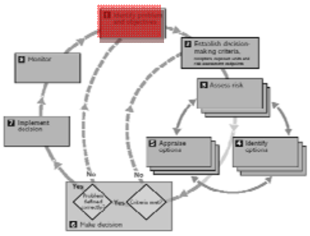


Figure 10/1: Stage 1 of the UKCIP framework

5.2.1 Importance of the stage

The importance of Stage 1 lies in understanding why the decision has been made and to identify the decision maker's broad objectives (Willows and Connell 2003). Also, this stage helps in identification of climate-sensitive, climate-influenced or climate adaptation decisions. Considering that the FM team was undertaking this exercise as a response to existing extreme events and that in future there was likely to be an increase in the same, the decision was considered to be a climate adaptation decision.

5.2.2 Key considerations

The problem question thus identified was stated as 'How to manage the risk of future flooding and overheating in the organisation's properties?' The related outline objectives were:

1) To achieve resilience in at-risk properties by causing minimum disruption to the organisation's operations; and
2) To implement resilience measure keeping in line with available organisational maintenance budget.

5.2.3 Stage description

In this stage the level of decision making is identified – i.e., whether the decision making is at policy, programme or project level. Since the prior decision making was at strategic level, the first decision making was considered to be a macro-level policy decision followed by micro-level (project level) decisions considering individual at-risk properties. The time span for the decision as agreed by the team was of 10–15 years, and this was a reflection of an FM strategy implementation every 3–5 years.

Only a limited number of FM team members were involved in decision making. This was due to regular involvement of the FM team in the built-asset maintenance and management aspects. Also, time and resources involved in higher-level involvement was not found to be conducive.

The wider group of stakeholders considered being the beneficiary of the decision were the decision makers in the organisation, the customers and the organisational staff.

The adopted methodology by the team was brainstorming (chosen from among many techniques available to the FM team – e.g. problem mapping, external consultation, focus groups etc. This choice was due to the low familiarity of the team with the future flooding and climate change issues.

A set of questions as provided within the UKCIP framework guidance were considered before deciding on a particular technique to be implemented for answering questions at each stage of the framework. Appendix 4 provides the description table for these general questions.

The key questions to be answered at stage 1 of the framework are presented in tabulated form in Table 3, along with corresponding answers formulated by the FM team.

Table 3: Key questions and answers towards fulfilment of stage 1 of the UKCIP decision-making framework

Key Questions for stage 1 of framework	Answers formulated by FM team
1. Where does the need to make the decision come from? What are the main drivers behind the decision? What beneficial objectives are intended?	The experiencing of a flood event at properties and the main drivers being the financial and functional loss experienced due to such event. The objective is to use the framework to manage the flood risk as efficiently as possible.
2. Is the problem explicitly one of managing present-day climate or adapting to future climate change i.e. Is the problem perceived to be a climate adaptation decision problem?	The problem is both managing the increase in flooding experienced now and the possibility of increased precipitation and sea level rise and occurrence of extreme events as put forward by climate change predictions. The problem is one of adapting to future increased flood risk, which may or may not be directly related to climate change.
3. If the main driver is not related to climate or climate change, is climate change believed to be a factor in the problem? a) If so, how important is climate change believed to be, relative to other factors? Is the problem perceived to be a climate-influenced decision problem?	Although scientifically climate change could not be associated to present flooding events in the UK, it is believed that these will increase and become a regular occurrence in future. Keeping this in mind, it was considered at this stage that climate change, reduced future cost and disruption to business activities were drivers for decision making. Climate change projections about increased precipitation and sea level rise would play a considerable part in decision making, in which case the problem was largely perceived as one of adapting to future climate change. Climate change is considered to be an important factor in maintenance management in relation to budget availability.
4. Is it a policy-, programme- or project-level decision?	Considering the number of properties at risk, it would be appropriate to call it a policy/-project-level decision.
5. Who or what will benefit or suffer as a consequence of the problem being addressed? Who are the key stakeholders representing those interests?	The beneficiary would be the business owners, facilities managers, the staff and customers in use of the properties at risk. There are no potential non-beneficiaries identified.
6. Have timescales been established for making and/or implementing a decision? Do these timescales constrain the time available for the decision appraisal, or vice versa?	The initial time frame for purposes of this study is 1 year. The decision/recommendation will be implemented at the end of the year and would be appraised at a later stage, the reason being the maintenance management strategy for 5 years could be constructed (depending upon changes required for the long term) and implemented in order to see the result, because the properties are faced with risk of flooding as each year passes.
7. Is the decision expected to provide benefits in the longer term (>10 years) or have other long-term consequences? Describe what they are, the likely time period, and to whom they may be important. (Decisions with long-term consequences are likely to be more sensitive to climate change.)	The decision made needs to be implemented and monitored to assess its long-term benefits. Reduced insurance premiums, recovery budget and effective business continuity (at the end of 5 years), increased value of the property (>10 years) and marginal or no loss due to climate-related disruption are all important benefits for the organisation.

5.2.4 Summary – stage 1

The completion of this stage was achieved through identification of the decision as one of adaptation to climate change and was considered at both policy level (strategic-level decision) and project level (decision with regard to individual property). The time span for the decision implementation was considered to be short term (≤10 years); this was due to annual and quarterly upgrades of the routine FM&O strategy within the organisation. The stakeholders' group consisted of organisational staff, customers, shareholders, higher-level (strategic) decision makers and the FM&O staff. While the involvement of the entire stakeholder grouping in the process was not possible, a team of FM&O staff was closely involved in decision-making framework implementation.

5.2.5 Researcher observation – stage 1

Owing to familiarity of the participant and use of a common language and terminology, the brainstorming exercise was completed with a series of informal discussions with the researcher noting down the answers to key question asked in stage 1.

Although participants were presented with the requirement to complete stage 1, as a result of unfamiliarity of the subject matter (UKCIP projection and decision making with climate change) an easily implemented brainstorming exercise was undertaken. This opened up many discussions, such as clarity on the resources required and their availability, and consideration of a sample of the commercial stock instead for the whole stock (with use of initial assessment).
This in turn was formulating part of consecutive stages.

5.3 UKCIP Stage 2 – Establish decision-making criteria

As the stage title describes, this stage facilitates the decision-making process by establishing the criteria against which the final adaptation options are appraised. The various systems and operational built assets (receptors) under likely future impacts are scrutinised. The higher-level and lower-level risk points for the receptors are established for formal risk assessment.

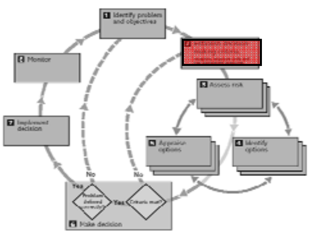


Figure 10/2: Stage 2 of the UKCIP framework

It is noted that the criteria for decision making will differ for different organisations, depending upon the attitude to risk and the culture of both the organisation and the decision maker.

The key questions and answers determining the decision and organisational criteria are presented in Table 4 below

Table 4: Key questions and answers towards fulfilment of stage 2 of the UKCIP decision-making framework

Key Question for stage 2 of framework	Answers formulated by FM team
1) What makes the correct decision? In other words, what are the criteria against which your options will be appraised in Stage 5? Criteria might include the risk of the option not succeeding, ease of implementation, cost, equity, public approval, public acceptability, etc.	The important criteria would be the a) Cost budget b) Ease of implementation c) Legislative boundaries d) Business need of the property.
2. What are the legislative requirements or constraints? For Government agencies, does the decision require an appraisal that explicitly considers both costs and benefits (as, for example, required by the Environment Act 1995)? Do guidelines exist that set out the approach that should be taken to the appraisal (e.g. DTLR, 2001b, HM Treasury, 2001 & 2003)?	There are no legislative requirements as far as addressing the risk aspects of the properties is concerned. The Health and Safety and fire safety requirements should not be compromised. Although any major catastrophe and its treatment will have to be reported in the CSR annual report and a feedback to BCP [Business Continuity Planning] and FM strategy, there are no legislatively binding guidelines adopted for assessment but the BCP appraisal needs to be carried out.
3. What are the rules for making the decision, given the uncertainty in climate change? For instance, is your organisation risk-averse, focused on maximising benefit, or focused on minimising cost? If risk averse, minimum (no or low) regret and precautionary approaches to decision rules should be considered.	The organisation is focused on minimising cost yet regenerating itself quickly in cases of extreme event impacts experienced. The initial investment in measures taken for minimising risk would need to accept the existing budget constraint till the time that any external financial resourcing is procured. The existing CO_2 reduction measures are taken as a result of CSR targets by procuring renewable energy contracts. This has not involved any initial investment. Consultation with the Carbon Trust is ongoing for implementing new measures and any funding avenues.
4. What is the decision-making culture of your organisation? Is the culture one of open and explicit decision making? Do different stakeholders need to be involved in the decision-making process? If so, how? Is the goal one of consensus or, if not, the creation of a demonstrably rational choice?	The majority of decisions are taken at board level, depending upon the business plan and market scenario. Different departments are given targets and budgets, which are achieved thorough different long- and short-term strategy implementations. A feedback loop from operational and middle management exists for the achievement of benchmarks. The involvement of strategic FM personnel (responsible for achieving targets) from various regions is necessary for a coherent implementation. Subsequent group meetings or workshops could be arranged at the end of this exercise to disseminate experience and findings.

5. Could the decision being considered possibly constrain other decision makers' ability to adapt to climate change (i.e. contribute to climate maladaptation)? Options or decisions that may constrain climate adaptation can be difficult to identify at this stage. They may be only apparent after Stage 5. If it is believed that the decision being considered may adversely affect the ability of other decision makers or stakeholders to manage climate change risks in the future, their interests and involvement in the decision-making process should be considered.	At present there is no department recognised whose ability to address the impacts would be affected, because the FM team is in the first instance responsible for addressing these impacts. If any department is recognised to be affected by the decision made by the FM team, it will be considered at a later stage.
6. Who is the ultimate decision maker?	Suggested solutions would be communicated to the head of workplace management, who in accordance with the budget constraints and other strategic consideration (taken at board level) would approve the measures.
7. Has climate change already been accounted for at a strategic level? If so, was consideration of climate change at the strategic level adequate? Does the strategy take account of all possible climate change outcomes?	The CO_2 reduction targets are already addressed in the CSR policy. The annual and quarterly workplace and energy strategies have put forward the measures to achieve the targets. At the moment the targets are within achievable bounds through procurement of the renewable energy contracts. Any further reduction targets will need additional measures in case future energy contracts are not procured. There is no long-term strategy or budget in existence for addressing the physical impacts of climate changes and increasing extreme events. At present, BCP exists as a measure to address the recovery from such impacts. Contingency budgets are used in some instances for repairs.
8. What resources are available to help you make the decision? This will help determine how in-depth your decision-making process can be, and what tools are appropriate to assist in the process.	Participation from FM professionals of the workplace team. Support from the present study and guidance. Existing and past property data. Any external support and guidance available from Government or other institutions. No financial resources are available to undertake additional technical consultation work.

5.3.1 Stage description

It was observed during this stage that there already exists and overarching organisational and facilities management strategy, together with allied contracts, which would act as boundary constraints for any decision made in later stages:

> ***"We already have the strategy for investment in [refurbishment] in our new asset and we are tied for at least the next three years in certain maintenance contracts." (FM manager comment)***

Recognising this constraint through consecutive brainstorming sessions, the FM team identified the receptors and exposure units and establish the risk end-points (the degree of risk posed to exposure units).

Since the organisation is from the banking sector, all retail banking branches, important corporate buildings and call centres were classified as receptors. As per the count there were a total of 90 properties which were classified as receptors. This was as a result of these properties having a recent history of climate-related flooding/overheating on the organization's maintenance database.

Since it would be difficult to undertake a risk assessment of all of the receptors, the team decided to take a sample of the built assets for doing that assessment. The Environmental Agency (EA) flood maps were referred to, as the prime concern to be addressed through this exercise was to make properties resilient to increasing future flood events:

> ***"I think we should refer to the [Environment] Agency to look for sample properties as we need flooding to be addressed first and foremost." (FM manager comment)***

With the help of those (online) flood maps, the team came up with three sets of properties at high, moderate and low risk corresponding to the level of flood risk addressed in the EA maps. As per this process, receptors (properties) and end points (levels of risk) were established, as set out in Table 5.

Table 5: Established receptors and end points

No of receptors	End points
37	High risk
6	Moderate risk
6	Low risk
21	New sites at moderate risk due to recent heavy rain occurrences.
70 total	

Although the EA maps at the time of the exercise did not include future climate changes in their indicative maps, the use of EA maps were envisaged as there was a common consensus in existence that with future climate change the risk of flooding in the existing at-risk properties will only increase. Although there would be additional sites which will be at risk of flooding in future due to climate change, taking the existing at-risk sites as a sample would be helpful in guiding the process for new at-risk sites.

> ***"[Flooding] will only increase in our existing [at-risk] premises with more rain, which is what we are experiencing with all this weather change [i.e. climate change]." (FM junior manager)***

Since the EA flood risk maps were used as basis for defining the level of risk, the assessment end points correspond to the levels of risk defined by the EA. This means that some 37 premises occupied by the participating organisation were at high risk of flooding 'High risk' is defined as where the chance of flooding in any year is greater than 1.3% (1 in 75); 'moderate risk' is defined as where the chance of flooding in any year is 1.3% (1 in 75) or less, but greater than 0.5% (1 in 200); and 'low risk' is defined as where the chance of flooding in any year is 0.5% (1 in 200) or less.

Since the team was already informed about the key UKCIP projections, they were able to attach probability and confidence levels of scientific projection to the assessment end points, as presented in Table 6.

Table 6: Assessment of end points in accordance with climate change projections

End points	High risk	Moderate risk	Low risk
Projection probability and confidence level	High confidence, high probability	High confidence, low probability	Low confidence, low probability
Operational aspects	Double or more than double insurance premium (compared to present state), decreased property value, financial loss, doubling of recovery budget. 8 or more days of business lost, doubling ofstaff complaints.	Moderate, ≥ 2 days of business lost, increased recovery budget (> present), increase in staff complaints (but ≤ doubling).	Disruption caused in number of hours open for business, maintained recovery budget and insurance premium, increased property or normalised property value, minimal increase in level of staff complaints.

At the end of the stage, the exemplar matrix in Table 7 was established which fulfilled the stage-2 requirement of the framework and acted as a matrix which could be used in future with newly at-risk properties.

Table7: Exemplar matrix

Objective	Criteria	Receptor and exposure units	Assessments endpoints (high, moderate and low)	Factors affecting assessment points
1) Minimise the disruption due to flooding caused by heavy rain and overburdened property drainage problems. 2) Manage and maintain properties at flood risk within budgetary requirements. 3) Decide on viability of the properties (out of 37 which are at 100% risk) being kept for future business up to the year 2020.	1) Reduction in the days/hours the premises (maximum a week after a major flooding) are closed due to flooding caused by heavy rain and overburdened property drainage problems by the year 2020. (Also flooding due to coastal / fluvial / surface water / groundwater.) 2) Minimum staff absenteeism during the flood event. 3) Reduction in spending on flood-related reactive maintenance by increasing flood resilience/preparedness in properties at high risk. (The % of reduction is not mentioned as any reduction achieved would be regarded as success).	1) Operational buildings 2) Customers 4) Staff 5) Maintenance management system of properties with flooding complaints.	1) 37/90 properties are at high risk (chance >1.3%pa) of flooding as per present EA maps. The response time to complaints from these properties has to be reduced. (Evidence: present research on flooding and the UKCIP02 scientific report indicates that there is high confidence in the occurrence of flooding due to amount and intensity of winter rainfall, sea-level rises. The evidence gathered for the UKCIP02 report is presented in Appendix 5.) Business continuity plans for all 37 at-high-risk properties in case of severe flooding. Implement measure in routine maintenance plan to mitigate flood damage. 2) 12/90 properties are at moderate or low risk (chance ≤1.3%). Reduction in complaints and level recovery budget.	1) Working hours 2) Maintenance schedule 3) Budget availability 4) Procuring contractors.

5.3.2 Summary –Stage 2

In summary, stage 2 establishes the criteria for a decision, dependent upon the attitude to risk (risk averse or risk containing) – for instance, the consensus was that the criterion of a reduction in the number of days of premises closure was dependent upon the attitude that since there is no certainty about climate change and that future climate impacts would be felt at a certain magnitude, in which case thinking in terms of business loss should prevail and risk preparedness should be adapted. Also influencing the objectives and criteria of decision making is the culture of the organisation.

As described in a previous chapter the participating organisation reflected a hierarchical organisational structure and the prevailing culture was that of defined roles and responsibilities, and of fulfilling strategic aims and targets. Very few attempts were made to go beyond a set role to achieve higher targets. Even then, the few attempts made were constrained with no further motivation and no higher-level participation.

The stage also clarified the receptors and system that were likely to be impacted due to future climate changes. It needed the help of existing EA data and maps, and the organisation's maintenance complaints database, for identifying sample properties that would be studied further. A total of 90 sites were assessed as having some amount of risk of flooding. Out of these, 37 sites were classified as having high risk while another 12 were classified at moderate and low risk in equal proportions. These were classified using the information in EA maps, which did not take future climate change into account in what they portrayed; but on the basis of information gathered from the UKCIP02 scientific report, a general perception within the team prevailed that with climate change the existing at-risk sites will only experience further severe and frequent flooding.

The clarity on assessment end points was a crucial element of the stage, whereby the team took account of business and climate projection data for establishing low, moderate and high-level end points. For instance, climate projections with high probability and high confidence and associated high financial and operational business were classified as higher assessment end points, while projections with low probability and low confidence associated with low business loss were classified as lower assessment end points.

5.3.3 Researcher observation – Stage 2

It was clear by this stage that although the FM team had a basic awareness about climate change occurrence and impacts, the understanding of scientific climate projections was not observed to be prominent – although the team was able to use the overarching findings of the UKCIP02 projections in their assessment.

The FM managers relied on their experience and perception and, keeping in mind the overall organisational culture, used the tried-and-tested method of using existing EA maps and the organisation's own maintenance complaints database for assessing properties likely to be at risk in the future due to climate change.

On the basis of a primary understanding of climate change projections, a prevailing perception existed that with future climate change the already at-risk sites would experience more extreme events and flooding and that the properties should adapt a precautionary approach to minimise the operational risk:

> ***"I think whatever the [climate] change is [caused by], we need to be at least prepared." (Decision maker comment)***

> ***"I think none of us understand the detailed science [of climate change projections] but I am certain that we all agree that things will become worse for flooding [at already at-risk sites]" (FM manager comment)***

5.4 UKCIP Stage 3 – Assess risk, (tiered stage).

This stage of the UKCIP framework is a tiered stage involving three tiers, where tier 1 assesses the preliminary climate change risk assessment while tiers 2 and 3 assess the qualitative and quantitative climate change risk assessment (respectively) involving tools and techniques for assessment which are more complex than the previous two stages.

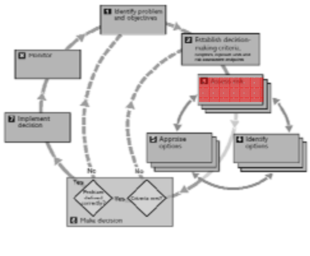


Figure 10/3: Stage 3 of the UKCIP framework

5.4.1 Importance of tier 1 of the stage

The tier-1 analysis helps in shortlisting the climate variables which could potentially affect the receptor and the options for adaptation. For the study under consideration, the FM team defined three climate variables and their potential effect on the receptors. The summary output of the UKCIP02 scientific report was referred to as guidance for this stage.

5.4.2 Description and key considerations of tier 1 of the stage

Answering the guiding key questions for the tier 1 helped in identifying the climate variables, which can affect the decision.

The guidance in the UKCIP technical report helped in characterising the climatic and non-climatic risks through key questions and answers for the stage, as presented in Table 8.

Table 8: Key questions and answers towards fulfilment of stage 3 tier 1of the UKCIP decision making framework

KEY Questions for stage 3 tier 1 of the framework	Answers formulated by FM team
1. What is the lifetime of your decision? Over what period are the benefits of the decision expected to be realised? This will inform the choice of climate scenarios to be used in future analyses, and how they are interpreted.	The time frame considered for the decision is 20 years, for which future demands would be assessed. If implemented, the benefits could be realised in the next 5–10years (considering the uncertainty in climate change and that the recent effects experienced would increase in future). Depending upon this, the most immediate climate change time series 2020 (2011–30) is to be taken into account.
2. Which climate variables are likely to be significant in relation to meeting your decision criteria? Does information on past variability in climate or past extremes of weather indicate potential vulnerability to climate change? Vulnerability to changes in mean climate may be less obvious, and therefore more difficult to foresee than vulnerability to changes in climate extremes.	Heavy rain and precipitation rates, extreme weather events (windstorms) resulting in flooding, sea level rise near the properties situated at coast are the main variables of significance here. The floods which occurred due to heavy rain in 2000 cannot be scientifically completely attributed to climate change, but there is high confidence in the scientific community that intensity and frequency of such rainfalls may increase in accordance with the output from climatic model runs. Also, gradually increasing summer temperature is to be considered. The complete information on flooding on various sites was difficult to gather as newly acquired properties would not always have an associated flood history and damage data.
3. How might future changes in these climate variables affect your decision and ability to meet your decision criteria? Are certain climate variables likely to be of greater significance than others? Judgements should be based on information contained within the latest UKCIP climate change scenarios. Climate analogues may also be helpful. Changes in the frequency and magnitude of extreme values of climate variables are more difficult to predict, and more uncertain, than changes in mean values.	Extreme rainfall frequency and intensity will affect the plans of making the properties flood resilient, demanding more maintenance budget and more non-operational days for the business. Also, a high confidence level for more winter precipitation as per the UKCIP02 scientific report will affect the flooding events due to decreased capacity of surface water drainage to cope with increasing amounts of rainwater. Historically, autumn precipitation in the UK has been high and has been seasonal for many flood events. Due to climate change the winters will be wetter, resulting in the soil retaining more water after a possible flood event in autumn and itself resulting in a higher number of flood events than in the past.
4. If an initial portfolio of options exists, is it possible at this stage to judge the potential significance of the impacts of climate change to the options? Is the risk posed to certain receptors likely to be of key importance to the choice of option?	There are some sets of options that exist at present. They include insurance premium arrangements, relocating ground-floor functions and important equipment above the flood level, floor refurbishment (replace carpeting with solid water-resistant flooring, move electrical points, arrange for staff to work from home if required to or from some other business premises, emergency staff from nearby area should be a standby in emergency, check and update site

	sewerage system, update roofing and guttering, liaise with highways agency, energy and communication providers for emergency supply and speedy recovery or provide generators on site, keep ready the disaster recovery plan including drying services and contractors and other suppliers. Check and establish the emergency contracts with suppliers as required, server room cooling capacity should be increased, with provision for additional coolers if required, for long-term solutions assess the cooling demand and options for natural ventilation in server rooms or other office areas. Replacement of equipment can be included in next maintenance cycle, while major system changes could be undertaken during refurbishment cycle. Staff dress code and energy efficiency, and cooling and heating control training, water cooler provision. (The probability and intensity of weather events such as flooding and heat in areas where properties reside will be important for deciding on appropriate option. % increase then historical flood events and consecutive hot spell will be of concern for routine working of the business and building services.)
5. Is there uncertainty regarding forecasts of particular climatic hazards or their associated impacts? Can the level of confidence associated with particular hazards and their impacts be determined?	At present there is more than 90% confidence in the occurrence of flooding at 37 sites without considering climate change, as per the EA maps. Also high confidence level in wetter winter; and confidence level in variability in spring and winter is medium to high.
6. Can any climatic variables or impacts be screened out at this stage – for example because they are not likely to affect the choice of option or because they would apply equally to all possible options?	Everything can be screened out except the ones which will impact flooding and overheating.
7. What other (non-climate) factors could also be relevant in relation to meeting your criteria? There should be an aim to limit the time and effort spent on data collection at this stage. The intention is to provide an indication (not involving quantification) of the areas where climate change risk could significantly influence the final decision.	Monetary and human resource limitation; also, limited expertise in flood resistance and understanding quantified data for UKCIP02 climate change data files. Organisational approach for climate change. Site-specific FM approach for risk assessment, management and climate change as whole.

A matrix of key climate variables and their characteristics affecting the decision was prepared, which is presented in Table 9. This allowed grading the confidence level in the assessment of links between variable and decision criteria.

Table 9: Climate variables and characteristics affecting the decision

Variable	**Magnitude and direction of change**	**Joint probability events and variables**	**Sensitivity of decision criteria**	**Confidence in assessment of link between variable and decision criteria**
Sea level	Increase (sudden in next 10 yrs)	Joint occurrence of high precipitation and sea level rise	Medium to high (have time to observe the change and relocate)	Low
Precipitation	Increase (monthly during autumn and winter)	Joint or consecutive occurrence of high winds and precipitation	High (increase in maintenance budget and non-working days)	High
High winds	Increase (sudden extreme winds resulting in storms, monthly during autumn and winter)		Medium to high (roof structure and windows /cladding joints maintenance cost)	Medium to high
Soil moisture	Increase (monthly)	Consecutive high precipitation	Low to medium (water ingress and retention may result in localised flooding)	Low to medium
Water run-off	Increase (during wet seasons and extreme rainfall)	Consecutive high precipitation and wet seasons)	Medium to high (risk of blocking the drains, resulting in small areas of property flooding)	Medium to high

The tier 1 of stage 3 helped the team in its preliminary risk screening due to climate change by establishing: (a) the time frame of the climate change to be considered (the 2011–2020 time series); (b) the climate variables which can affect the decision; and (c) their variability and the confidence level attached to the expected changes according to the UKCIP02 scientific report. The team also acknowledged that the limited finance and expertise available on the subject might affect the final decision.

5.4.3 Description and key considerations of tier 2 of the stage

Tier 2 of stage 3 was adapted to further assess the qualitative and generic quantitative risks on the basis of the climate variables and projection time series identified in tier 1. The key question and answers for tier 2 of this stage are presented in table 10 below.

Table 10: Key questions and answers towards fulfilment of stage 3 tier 2 of the UKCIP decision-making framework

KEY Questions for stage 3 tier 2 of the framework	Answers formulated by FM team
1. Given the various options identified previously, what are the risks of failing to meet your criteria: a) Posed by climate change? b) Posed by non-climate factors? Forecasts of future values for both climate and non-climate variables will be required. In most cases these forecasts will be scenario-based in order to account for sources of uncertainty. Criteria will be represented by a number of defined receptors and assessment endpoints (refer to Stage 2).	Risk posed by climate change is 15% increase in winter precipitation by 2020 (medium High Emissions scenario). 100% confidence that the 37 properties will have 1 in 75 chance of flooding without climate change, which can only increase due to increased precipitation through winter – closure of the premises for a longer time period resulting in loss of working days and business in monetary terms. Recurring maintenance due to increased rain and flooding and possibility of rendering the premises obsolete. Failure to acquire insurance in future if insurers do not agree for insuring the flood-prone sites. Non-climatic factors: other business in surrounding area may benefit from closure of flooded premises. The flood barrier planned by the Government may take longer than anticipated to be constructed. The selling price of the premises may be lower due to residing in a flood zone.
2. What are the most important consequences? Which are the key hazard factors? How are the consequences dependent upon the hazards? Risk assessments, including estimates of probability, will be contingent on the particular scenario or scenarios upon which they are based.	The most important consequence is the permanent closure of the site due to increased sea level rise or recurring extreme rain events, as these hazards will result in unavailability of the site and staff for operational purposes. Much of the time, as per medium–high end of the High Emissions scenario, there will be a high confidence that winter rain will increase in the area. The sites within these areas will be constantly monitored and further resources would be allocated if required.
3. Are some of the options more vulnerable to these factors then others?	None of the options except the flood levy in high sea-level rise areas are vulnerable to extreme recurring winter rain and sea level rise events (near coasts).

4. What tools should be used to analyse risks? Do these reflect the scale of the problem, its complexity and data availability?	Refer to Appendix 7 for exemplar assessment. Risk assessment = Probability × consequence where Probability = a chance a particular event will occur and Consequence = the impact the particular event can cause resulting in desirable or undesirable outcome. A primary cost–benefit analysis method using medium–high scenario projections (Appendix 7) was used as a guide. A risk matrix table to be constructed for every site, which is at 100% risk as per EA maps. This is found to be the best option considering the present data availability and expertise. (semi-quantitative)
5. Could other tools be adopted which would allow more explicit consideration of climate change risk, including estimates of probability, analyses of uncertainties and the significance of key assumptions? In-depth detailed quantitative studies (tier 3) will usually be dependent on further data collection and the development of risk assessment models. What would be the advantages or disadvantages of adopting alternative risk assessment tools?	At present the risk assessment has to be limited to tier 2 for qualitative analysis, as the FM team do not have resources for external consultancy and data availability for quantitative analysis. Also, the level of analysis reached thus far is likely to achieve the desired criteria and objectives. Any further quantitative analysis would need to be driven from higher (strategy–making) decision makers.

Answering the key questions for tier 1 and tier 2 revealed that the further quantitative analysis would require expert opinion and knowledge along with detailed data for individual sites and buildings at risk of flooding. Since this data was not available to the FM team during the implementation stage, it was decided to gather them from external sources such as local authorities.

5.4.4 Local council questionnaire

The FM team believed that it was necessary to gain local knowledge about the high-risk sites and also gather information from the local councils on any support systems that are provided by the councils to the local community and businesses in severe conditions, because it would not be possible for the organisation to take all the adaptation measures (e.g. construction of temporary levee). For this purpose the basic information had to be collected on council flooding preparedness before any further detailed inquiry was able to be made.

With this in mind, a web search of sample of council websites was performed and this revealed the following:

- Council websites have preliminary information regarding flooding and are supposed to have an emergency plan. Most of the councils would have an emergency hotline open for help and support.
- The support provided by the councils is in the form of an initial flood warning system (initially activated by the Environment Agency) which is through fax, e-mail or other media this seems to be in place with every council. In addition, some of the councils provide sandbags at a cost or free before and during a flood period, but some do not provide them and advise procuring them beforehand.
- In the event of road closures or disconnection of power supplies, the authorities in charge (such as the power supply companies, the water companies and the highways agencies) are directly responsible for all the above services and are not entirely in the council's hand or responsibility.
- The council would try to get the things back to normal as quickly as possible in coordination with these authorities – but it might take from days to months.

- In the case of a flood caused through heavy rainfall and overflow of drainage, the drainage authorities are responsible. In the same way, the highway agencies are most times responsible for the upkeep or road works so that they do not flood. In cases of road flooding, these authorities would try their best to get things back on track, which can once again take days or months.

To get more information about the council's role and support in cases of flooding, a questionnaire was prepared (see Appendix 6) asking about the following:

- The various flooding events that had occurred within the council area, with their severity levels
- The action taken before flooding with regard to a warning system, the closure of roads, the effect on electricity and other services, and any relocation of people if required
- The action taken during flooding with regard to security measures taken to avoid damage to private property, and the activation and effectiveness of any emergency plan
- The action taken after flooding by means of a recovery plan, including cleaning and opening the roads, reconnecting electricity/gas/water supplies, and drain clearing
- Any anticipated future risk of flooding advised to the council and its causes, with any plan in place to reduce the risk of future flooding.

5.4.5 Results and analysis of council questionnaire

While analysing the questionnaire replies from local authorities, it was observed that one of them invoked the Freedom of Information Act 2000 and others were found to be very much incomplete, which implies that there is not much flood data-recording taking place within councils (although this is found to be changing in recent years as a result of the introduction of the Climate Change Act 2008). Poor record-keeping in this context had been assumed from the prior web search before the questionnaire, but it was once again confirmed.

In total only seven replies (including one evoking the Freedom of Information Act 2000) were received, out of 25 questionnaires sent out to councils where the participating organisation had properties at highest risk of flooding according to list put together with the initial search from the

Environment Agency website. From the acquired results it could probably be pointed out that at most the councils could:

- Collaborate with the various authorities during and after flooding
- Work as a primary warning authority locally and to local businesses once it receives any flood warning from the Environment Agency
- Have an emergency plan, which in the majority cases can be procured from their websites. The council needs to consult the Environment Agency for approving any future development in the flood plain zones, and this has been emphasised by publication of PPS 25, which sets out policies to planning authorities to:
    - Ensure flood risk is properly taken into account at all stages in the planning process.
    - Prevent inappropriate development in areas at high risk of flooding, and
    - Direct development away from areas at highest risk.

Through the questionnaire survey it was observed that a higher level of coordination between the Environment Agency and local planning departments is required. This has been emphasised in the LCCP (2006) report and the Pitt review (2008). The LCCP report mentions the need of partnerships between different government organisations and across geographical boundaries, and a need for clear communication and engagement with authorities, business and the public to achieve successful adaptation for the changing climate.

A suggestion has been made for a forum involving various agencies to share information on drainage and flooding to help with managing flood risk through a range of measures. Although the Government agencies need to be at the forefront of managing the risk, coordination among the agencies is primary objectives which need to be fulfilled.

The scenario just described has been altered now with the ongoing research in the area and the requirements of the Climate Change Act 2008 and the NI 188 guidance for local councils, which requires those councils to undertake structured risk assessment and suggest adaptation options.

At the end of tier 2 the FM team had semi quantitative data which was not enough for undertaking a tier 3 of the assessment stage 3, thus restricting the implementation of the UKCIP framework till Tier 2 of stage 3.

5.4.6 Summary – Stage-3 assessment process

During stage 3 implementation, the FM team was able to identify different climatic variables, namely changes which could impact their operational function and physical aspects of the built assets. The variables causing particular concern were the higher precipitation rate during winter, high winds, a sea-level rise and a mean temperature rise. The probability of these events occurring was considered with the scientific confidence level attached to them. The variable changes with high and moderate (likely) confidence levels were considered in a further assessment.

The assessment made was qualitative and semi-quantitative in nature, owing to the unavailability of historical site-specific climate damage data, an absence of micro-level climate change projections over a short time period (5–10 yrs), and the FM team's relative lack of understanding of detailed scientific projections. The assessment process followed is outlined in Figure 11.

Assessment process

STAGE 1:
Past climate event:
1) Past property records
2) Local authority and surrounding business + archive
3) Physical survey (depending upon site impact to business)

→ Magnitude (severity) and likelihood (return period)

STAGE 2:
Damage (consequences):
1) Damage to building components (ext wall, partition, services, floor. etc)
2) Business operation disturbance
3) Insurance cost and increased premium.

→ Cost

→ Level of damage minor, low, moderate, high, sever

- Damage description
- Level of damage
- Cost of damage / repair

- Ext wall
- Int wall
- windows
- flooring
- partition
- basement

- No of days closure
- Cost to business /day
- Imp of business operation
- Cost of second site operation
- Cost on after event staff support

STAGE 3:
Measures taken:
1) After-event procedure
2) Any permanent measures implemented.
3) No measure, property under observation
4) State of property and performance after the event

→ Effectiveness of measure: Not very effective, effective, moderately effective, very effective, extremely effective

STAGE 4 :
Future changes:
1) Site specific probability
2) Confidence in projection
3) Risk in next 30 yrs (low, high and medium scenario to calculate three level of risk) = Past damage data (overall cost) × probability (H, MH, L scenario) (UKCIP costing methodology)

→ Costing to make strategic case

STAGE 5:
Likely damage in addition to previous damage experience. In absence of previous data, assess the likely damage and repair-work required (use external guidance and source).
1) Cost of damage to individual building component or repair-work required.
2) Present cost of business disruption
3) Increase insurance premium.

→ Individual component damage cost × Probability = Future damage risk in £

STAGE 6:
Options:
1) List of options considering the building component damage.
2) Life cycle costing for each option to evaluate the cost-effective measure.
3) List of cost-effective measures + business criteria + ease of implementation.

→ Bank of option to be Implemented depending on repair and refurbishment cycle.

Fig 11: Assessment process observed by the participatory FM team

Because of the unavailability of micro-level data and in the absence of any information available from the local authorities, the FM team had depended upon the existing information available from the EA maps to assess flood risk. The perception prevailing here was that flood risk for already at-risk sites at present will increase due to future climate change effects. The sites identified from the maps were assessed in relation to regional projections outlined in the UKCIP02 scientific report and the sites' business importance. These were rated at high, moderate and minimum risk in accordance to existing risk-level labelling used within the organisation.

The FM team had used existing and past experience of climate-related events in the assessment process as outlined in stage 1 to 3 of the assessment process shown in Figure 11. This consisted of gathering data on past experiences of climate events (i.e. the nature of the event, its severity, the consequences in terms of financial loss from damage to property components, measures implemented to deal with the problem, and the effectiveness of the measures. This became a basis on which to anticipate the future impacts in line with climate change projections outlined in the UKCIP02 scientific report.

On the basis of past and existing experiences, at stage 4 of the assessment process the team were able to identify climate change variables the changes in which were likely impacts on the organisation's built assets. A preliminary matrix of these variables and their impacts were prepared, as shown in Table 11.

Table 11: Preliminary matrix prepared by participatory FM team

Variable (for time series 2020)	Confidence level	Likely % increase	System and receptor affected	Impacts	Consequences	Options	Favoured option implemented on basis of initial criteria

Stages 4 and 5 together had adopted semi-quantitative assessment methods for costing the likely climate change impacts on the participating organisation's built-asset portfolio. These stages had taken the likely damage data from past events and combined it with the future event probability to obtain a future cost of climate change impacts. This was essential to make a financial case to gather strategic support. The costing methodology was based on the guidance presented in *Metroeconomica* (2004) (see Appendix 7 for details).

At this stage a secondary matrix, as presented in Table 12, was developed to support present and future decisions.

Table 12: Secondary matrix prepared by the participatory FM team

Climate variable	Events occurred	Frequency of events occurred	Receptor	Consequences	Adaptation action/ reactive action + cost	Residual risk after reactive action	Built asset importance for business	Future changes	Likelihood and confidence level of the future changes	Predicted Impacts and consequences (qualitative and quantitative)	Possible adaptation options	Level of estimated risk without adaptation	Level of estimated risk after adaptation
Precipitation (Rain)													

At the end of the assessment process, a bank of favoured options was developed along with trigger points at which the adaptation action would be initiated in the future. The trigger points were established as a result of uncertainty attached to projections and the lack of micro-level projections and impact detail, without which a complete costing and financial case was not possible to be established for strategic agreement. The strengthening of business continuity planning, disaster recovery planning and insurance cover were favoured as these were easy to implement without disturbing the routine working systems.

This pattern in organisational adaptation is also noted by Berkhout et al (2004), who pointed out that in the absence of strong climate change signals and an uncertainty of benefit from adaptation measures, organisations are unlikely to adopt the trial-and-error method to routine practices.

5.4.7 Researcher observations – Stage 3

It was observed that the FM team had developed a precautionary approach in the presence of the uncertainty associated with the climate change projections. Also, the perception persisted that, overall, future climate change impacts – especially increased winter precipitation; sea level rise and overheating in summer months – would pose an increasing risk to built assets and operational activities. The increased precipitation events were of particular concern.

This perception and overall attitude was reflected in the choice of scenario (medium–high and high emission) for risk assessment purposes, with a view that projections at the higher end would give more margins to manage risk.

By the time they had reached the risk assessment stage, the FM team had developed a moderate understanding of the decision-making framework, climate change scenarios and related projections. In spite of this, their belief in human-induced climate change remained weak. As a result, undertaking a forceful strategy and strong action for climate change adaptation was resisted to some extent:

> ***"We can assess the risk for future reference but it is still not clear [that these climate change impacts] will happen and that CO_2 is causing these [climate] changes." (Decision maker's comment)***

A common consensus among the FM team existed that strategic importance should be given to climate change adaptation and especially to flooding and overheating problems. This was expected to increase the operational budget and, in turn, help in making sites more resilient, based on the matrix and assessments worked out using the UKCIP decision-making framework.

5.5 Summary of the organisation's implementation process

The overall implementation process by the participating organisation for taking mitigation and adaptation action against climate change, including the different framework stages and their outcomes, is summarised in Table 13. In addition, Appendix 8 gives a diagrammatic representation of the implementation process. Although a range of climate impacts were considered, the two impacts that were perceived to be most important to the organisation were flooding and overheating, with flooding being given the highest priority – and primarily because the organisation had already experienced business disruption due to flooding events. With the problem defined, the next stage was to identify which of the organisation's built assets were currently at risk, or likely to be at risk, as a result of future climate change. This task proved more complicated than was originally envisaged.

The available climate scenarios (as per UKCIP02) were able to give future projections over wide geographical areas, but lacked specific probabilities of occurrence at the micro level, as a result of which site-specific quantitative risk assessment proved difficult to undertake. Although higher-resolution climate projection data was available, the UKCIP team has stated that this does not imply that detailed climate change information is available at the 5km scale, as there are many local climatic influences and feedbacks at this level that could modify the general pattern of change. Similar concerns are also noted by Luc Salagnac (2007) and O'Brien et al (2004). In light of these concerns, the Environment Agency flooding maps and information from local councils was used to make site-specific (at the individual building location level) flood risk assessments.

The decision to use the EA data was a pragmatic one based on the views of the participating organisation's facilities management team, who argued that buildings located in areas already prone to the risk of flooding are likely to face increased risk in the future. These predictions they had confidence in and felt able to defend to senior management. Whilst this may appear a somewhat short-sighted approach, it is in line with the suggestions by Willows and Connell (2003), who identified a lack of understanding of climate change projections and related uncertainties as a key issue in assessing the risks associated with future climate change amongst business decision makers.

Table 13: A summary of outcomes relating to framework stages

Outcome / **Framework stage**	**Concise outcome**
Stage 1 – Identify problem and objectives	Consideration of the problem was based on experience of a flood event and consequent financial loss. The criteria were to look for ways to adapt to present and future climate-related flood events (and overheating). Climate change will be an important aspect in deciding on the adaptation measures. The scale of problem was deemed to be at the project level (i.e. operational). The decisions were expected to provide short-term and long-term benefits.
Stage 2 – Establish decision-making criteria	The attitude of the participating organisation towards risk was considered along with the level of risk acceptable (risk threshold). The major receptors were business function and built assets. Flood maps were used to decide on upper, medium and lower thresholds of risk to the properties under review (and these levels are likely to increase or remain the same in the event of future climate change).
Stage 3 – Assess risk (tiers 1 and 2)	Precipitation, extreme rainfall, a coastal sea-level rise, and summer temperature were regarded as variables of interest. The medium–high climate scenario with timescale of 2020 was considered. The

(Stage 3 tier 3 and stages 4–8 (4- Identify options, Stage 5- Appraise option, Stage 6- Make decision, , Stage 7- Implement, Stage 8- Monitor) were not undertaken at the required level of detail.)	limitations of existing measures were considered (resistance and resilience to flooding). Although uncertainty was looked at, it proved very difficult to persuade the organisation to consider further data collection and quantitative assessment and thus consider long-term planned adaptation interventions. A qualitative and semi-quantitative assessment and matrix was developed to assess the likely risk and resilience of the sample properties. Due to time constraints, this matrix was not fully tested.
Coping strategies	As a consequence of the participatory study, the organisation strengthened its business-continuity and disaster-recovery plans. High-risk properties were placed under 'on-going observation' and flood-resistant refurbishment contingencies were identified for high-risk sites. Further research on the business value of at-risk sites and a strategy for disposal or continuing acquisition was considered.

By way of compromise, the research team extrapolated future flood assessments by combining the existing flood risk maps with the wider macro-level climate change projection. These enabled the team to augment the list of buildings that were at ‘known risk’ with those that were at ‘possible risk’. However, much of the implementation process remained qualitative or semi-quantitative in nature. The implementation of quantitative risk assessment methods (e.g. Monte Carlo method, Bayesian method) were not pursued for probabilistic risk assessment due to a lack of micro-level probabilistic climate-change projections and the unavailability of historical data on property damage (cost) and business interruptions as a result of previous flooding events.

It was also difficult to establish validity for investing in elaborate quantification of the impacts of future flooding on built-asset management plans (including adaptation strategies) as a result of (a) the unpredictable cycle of acquisition and disposal of built assets in response to business demands (“Why invest in protecting a building against future flooding if we may not occupy it in five years’ time?”) and (b) the 30-year time line for climate change risk compared with a business and facilities management strategy-upgrade time period of 3–5 years.

As a result, the organisation decided to adopt a responsive strategy for climate change adaptation (keeping a watching brief and only intervening when a problem presents itself) until such a time as the level of certainty surrounding the impacts was reduced or the risks more clearly quantified. In adopting this strategy, a number of trigger points were established against which further detailed surveys and quantitative assessments could be made.

In cases of flooding, the most favoured long-term strategic option was that of strengthening business continuity planning through risk transfer (insurance) and the provision of temporary flood defences where required (to reduce premiums). Properties rated as high risk and where a recent flood event had occurred had flood resistance and resilience measures planned as part of the next normal refurbishment cycle, depending upon the budget availability; this could involve moving equipment above the flood level, replacing carpeting with hard water-resistant flooring, installing flood gates etc. The relocation of the business operation from an at-risk property (even on a temporary basis) would be considered if persistent climate-related extreme events were experienced. The realisation of these measures will once again depend upon achieving strategic and financial support.

In terms of immediate operational adaptation, routine maintenance was extended to include more regular gutter cleaning and drainage system testing; maintaining roof tiles and monitoring the façade of buildings for any water ingress. The main business-operational measure was an extension to home-based working (which was already being promoted as a part of a mitigation drive).

The implementation of the UKCIP framework within the participating organisation gave rise to an assessment process and adaptation process presented in Figure 12.

The assessment process was the result of implementing the framework and FM responses in adapting the framework as per their organisation's conditions. An explanation of these can be found in subsection 5.4.6. Further validation of the assessment process was not possible due to time constraints in implementing the UKCIP decision-making framework with other organisations, where these processes will reflect factors such as organisational decision-making, strategy approach and culture, which could differ from one case to another.

The adaptation process was formulated by analysing the process of implementing the UCKIP decision-making framework through participatory study with the organisation. The stages of the adaptation process were characterised by aspects such as experience of an extreme event, associated perceptions and an ability to identify future impacts. Read in a sequential format and in accordance with implementation of each stage of the UKCIP decision-making framework, these aspects help in outlining the adaptation process, which FM professionals of a commercial organisation are anticipated to go through.

The detailed explanation of this process is provided in Chapter 8, where it is supported by the result of logistic regression analysis performed on the questionnaire survey responses of British Institute of Facilities Management (BIFM) members. The questionnaire survey of BIFM members was undertaken to achieve further validation of the adaptation process observed in the participatory study. The similarity between the observed adaptation process in the study with the wider adaptation concept of risk experience, risk appraisal and adaptive capacity is also discussed in Chapter 8.

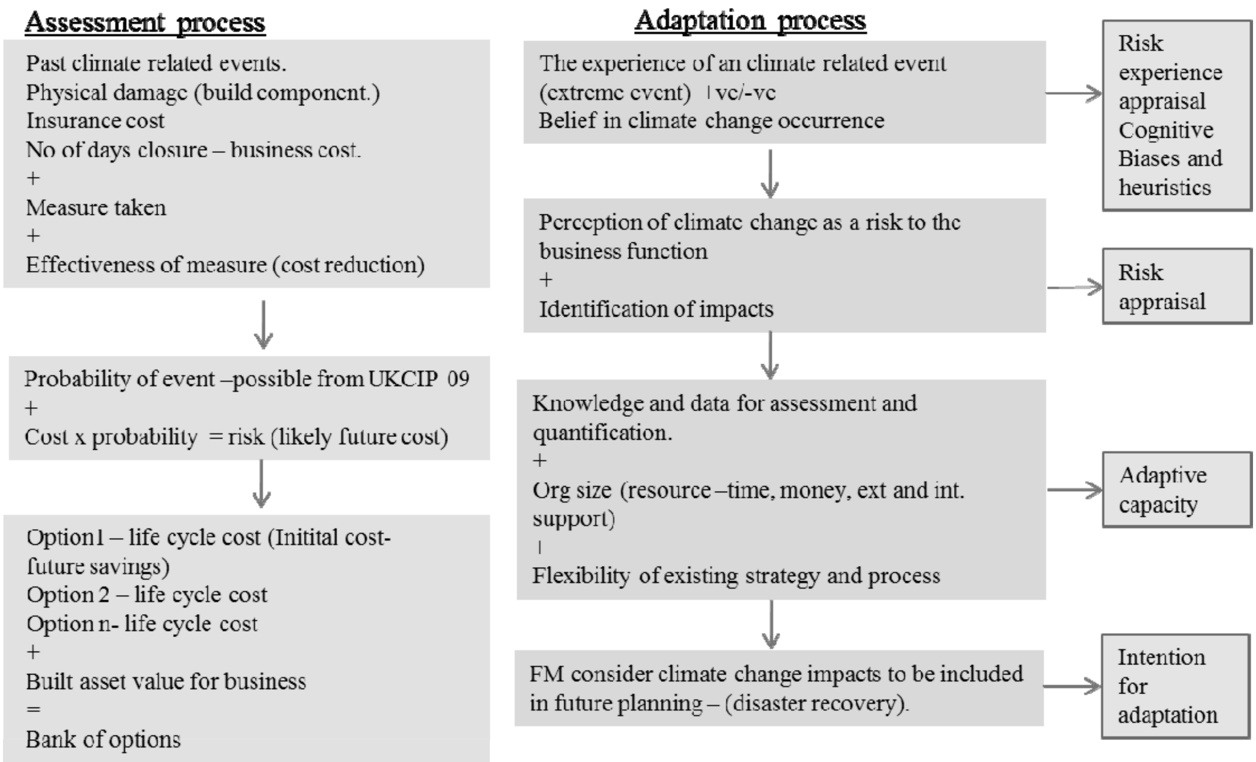


Fig 12: Overall assessment result and selected adaptation options

5.6 Conclusion and need for further validation of results

As a result of the participatory study, it was observed that the UKCIP decision-making framework remained only partially implemented, reasons for which are pinpointed below.

1) The organisation's and the facilities managers' perceptions of risk, associated with belief in the occurrence of climate change, affects the approach taken.

This was observed to be one of the key aspects in UKCIP framework implementation, which is also highlighted by Willows and Connell (2003) when they state that the organisational attitude to risk will affect the final decision.

It was observed that past experience and financial loss triggers a perception of future climate-related impacts, because risk and a perception related to risk persist (due to the wider importance given to climate change in the public domain) that in the future extreme events will cause more disruption, and even though the belief in human-induced climate change remains weak. This situation, coupled with other financial and organisational internal capacity constraints, limits the adaptation process to some extent.

2) Adaptation is seen as operational, while mitigation is strategically driven with long-term planning and adaptation action occurring as a reaction to a weather-related or extreme event.

A consensus existed that, as a result of wider mitigation regulation, the commercial sector needed a long-term targeted mitigation strategy and had to make it financially viable. Energy prices also contributed to this to some extent. This had made mitigation a strategic agenda and owing to set targets measurable actions were undertaken. In contrast, adaptation had no strategic impetus and was primarily seen as an operational risk for which, maintenance budget adjustments were to be made as and when required. Long-term planning for such a risk was a new concept, which has not yet made it to the forefront of organisational thinking.

3) A number of areas of concern remained unresolved: reliance on past experience of weather events; difficulty in translating climate change projections into business operational risk; uncertainty relating to climate change projections; and an absence of micro-level probability data.

Although through the implementation exercise the participatory FM team was very much acquainted with the UKCIP decision-making framework and the UKCIP02 climate projections, it was difficult for the team to translate the projection into operational risk. For instance:

> *"A 2-degree rise in temperature or 5% increase in precipitation to the 1960 base line is confusing for me to relate to. What I need to know is what I will face in the next three years so I can budget for it next year." (FM manager comment)*

The uncertainty and lack of micro-level climate change projections were also seen as a barrier. It was hoped that the site-specific past extreme-event damage data would be possible to gather from the relevant local councils, but the survey with the councils found that it was not possible to gather such data at the time of the study.

5.6.1 Validity of findings and the next steps

Citing Yin 1984, Gable (1994) argues that the study of a single case provides the opportunity to ask penetrating questions and to capture the richness of organisational behaviour, but the conclusions drawn may be specific to the particular organisations studied and may not be generalisable. In line with this, citing Lee 1989, Gable (1994) identifies four corresponding problems with singular-study research: a lack of controllability, deductibility, repeatability and generalisability, where the latter two limitations stem largely from the lack of power to randomise.

Nevertheless, it has been suggested by Yin (1984) (as cited in Gable (1994) that study of a single case is appropriate if the objective of the research is to explore a previously unresearched subject – as is the case in the present study (where the UKCIP decision-making framework was for the first time being used by a commercial FM department at the time of the research). In spite of this, it was also necessary to test whether the observations made during the study were specific to the participating organisation or represented a wider generic view of facilities managers. It was believed that ensuring this would also be able to address the two important limitations of the singular-case approach, namely repeatability and generalisability. Citing Jick (1983), Gable (1994) mentions the importance of how survey research can contribute to greater confidence in the generalisability of a set of results. By studying a representative sample, the survey approach seeks to discover relationships that are common, thereby providing a basis for generalised statements about the object of study.

In light of this thinking, a questionnaire survey was formulated, to be undertaken of professional facilities managers (BIFM members) based in the United Kingdom, with the aim of confirming (or otherwise) the participatory study observations found. Based on the key observations of the study, the questionnaire survey made three key enquiries:

1) What are facilities managers' perceptions and opinions about climate change (mitigation and adaptation)?
2) Does past experience of an extreme weather event change a facilities manager's perception of climate risk (in terms of business function / asset management) and is this the key to implementing adaptation measures?

3) What is the nature of climate change adaptation and mitigation actions – are they strategic or operational?

The questionnaire survey is the subject of the next chapter, and the results therefrom are discussed in Chapters 7 and 8.

Chapter 6: Questionnaire survey

The participatory study phase used an online questionnaire survey to validate the participatory study observation with the wider FM community. In this chapter, section 6.1 presents the web-based questionnaire approach and the reasoning behind it, including why the BIFM (British Institution of Facilities Management) community was selected as target respondents. The design of the survey, hypothesis and operational variables, along with the pilot survey results, are reported in section 6.2, while section 6.3 talks about the responses received, data gathering and transformation, and selected statistical analysis. Section 6.4 summarises the chapter content.

6.1 Online survey and design

As noted in Chapter 4, this research has adopted a sequential mixed-method approach where the qualitative participative observation study was trailed by a quantitative survey. This was done primarily to ensure the validity of the concepts generated from the qualitative study within the wider facilities management community.

As noted above and earlier in Chapters 4 and 5, members of the British Institute of Facilities Management were chosen as a targeted population to carry out the questionnaire survey as:

- The BIFM represents the largest group of facilities management personnel across the United Kingdom, providing a mix of participants from various business sectors
- The BIFM assisted by making certain that facilities managers in different posts across different sectors would receive the questionnaire
- It would be possible to make a comparison about FM perception and action between different sectors and across the different levels of post amongst facilities mangers
- The questionnaire could be sent across the whole of the UK.

The disadvantages to the approach offered were twofold: I was difficult to classify business sector details from the information in the BIFM database; and the contact details in the database only consisted of members' e-mail addresses, which required the questionnaire to be web-based. These disadvantages were resolved by including questions inquiring about a respondent's post, the sector they belong to and also the size of the organisation they worked in. This made sure that respondent from private-sector organisations that were senior facilities managers or facilities managers could be identified easily.

Couper (2008) identifies an online survey simply as a survey where data is collected via the internet. A further distinction is made by Couper (2008) between 'client-side' (i.e. e-mail-based) surveys, where the survey is answered by respondents via e-mail or completed in a word–processing document for sending across at a later time, and 'server-side' (i.e. web-browser-based) surveys where the questionnaire is answered in real time using the interactive features generated by a script on the web server or other program. Since the e-mail-based survey has a disadvantage of compromising security and confidentiality, a web-based real-time survey was adopted.

The survey questionnaire was formulated using SNAP software designed for generating online questionnaire surveys and performing analyses. The software is published by SNAP survey and was chosen due to its in house availability to the researcher and it added analysis ability. The software allowed a systematic approach to formatting the survey questions and distributing them to the intended population as it helped in:

- Formatting and colour-coding various components within the survey – for example, the instructions and questions, which were considered primary elements, were colour-coded differently from the interactive buttons and navigation bars, which made the questionnaire clear and legible (and further details on questionnaire presentation are covered in Chapter 3)
- Uploading the survey onto the University of Greenwich server, generating a web link, and sending out the invitations explaining the research, with an embedded web link to the intended population for completion of the survey
- Importing the responses into the software ready for generating an initial analysis or exporting the responses to other analysis software such as EXCEL and SPSS.

The questionnaire formulated using the SNAP software was tested with colleagues on three occasions before uploading the pilot questionnaire, so as to ensure the clarity of layout and for any technical or language errors.

6.2 Questionnaire design

Every piece of research has two constituents: research design and research technique (Oppenheim 1992; Creswell 2009). The overall research design (a mixed-method approach) has been discussed in Chapter 3. The research techniques could have varied across participatory study, action research, focus groups, interviews, postal questionnaires and online survey. As mentioned by Oppenheim (1992), the application of a particular technique is sometimes dependent upon the targeted population and the wider aim of the research – which is the case for present survey because the choice of a web-based survey was driven by the limited means of contact of the target population.

For a questionnaire survey design, Oppenheim (1992) puts stress on the specification of operationalised aims, i.e. specific issues or hypotheses, which should identify the variables and measurements to be tested. The operationalised aims supporting the hypothesis for the questionnaire were derived from the overall research design and participative observation studies.

On the basis of the qualitative study conclusions, the research questions for the questionnaire survey, a hypothesis and the related variables were all identified. These were categorical, continuous or discrete in nature.

To verify the hypothesis it was essential to ask two-tiered questions whereby an answer given to the primary was verified by asking secondary questions related to the concepts behind the primary question. For example, the questionnaire enquired about the participants' knowledge of climate change impacts via a rating scale, and the answer for this was verified at a later stage by enquiring about the participants' awareness of initiatives such as the Carbon Trust and UKCIP.

The measure of correlations amongst other variables was used to validate or reject the hypothesis. Table 14 outlines the findings of the participating organisation's observation study, the derived research questions for the questionnaire survey, the hypothesis and the related variables.

Table 14: Derived questions, hypothesis and variables

Participation observation conclusions (Ob)	**Derived questions (Q)**	**Hypotheses (H)**	**Variables (V)**
Ob1) The organisation's and FM managers' perceptions of risk, associated with a belief in the occurrence of climate change, affect the approach taken.	**Q1)** What are the facilities managers' perception and opinion about climate change (mitigation and adaptation)?	**H1** – Climate change is seen as an opportunity for new services, products and financial saving. **H2** – FM environmental inclination is presumed to be high and it may affect their belief of climate change occurrence and in turn their action, especially for mitigation.	**V1)** Perception of climate change via NEP scale rating. **V2)** Agreement (or otherwise) with natural or human-induced climate change and Government action.
Ob2) Reliance on past experience of weather events. Difficulty in translating climate change projections into business operational risk. Areas of concern centred on uncertainty relating to climate change projections and an absence of micro-level probability data.	**Q2)** Does past experience of an extreme weather event change a facilities manager's perception of climate risk (in terms of business function / asset management), and is this the key to implementing adaptation measures?	**H3 -** The long-term climate change impacts are less likely to be addressed compared with the experience of an extreme event, which results in a perception of climate change as a risk to the business function (due to losses experienced). It is the prime reason for FM to identify and consider future climate change to be included in disaster recovery (risk assessment). **H4** – FM largely unaware of much of quantitative climate change risk assessment and adaptation initiative such as UKCIP.	**V3)** Experience of an event. **V4)** Climate change inclusion in risk assessment. **V5)** Climate change adaptation and mitigation initiatives.
Ob3) Adaptation is seen as operational, while mitigation is strategically driven with long-term planning and adaptation action occurring as a reaction to a weather-related or extreme event.	**Q3)** What action has been taken for climate change adaptation and mitigation (and are they strategic or operational)? **Q4)** What are the correlations between adaptation, mitigation and operational and strategic planning?	**H5 -** Mitigation measures are driven through CSR (legislation compliance) and financial gain (through reduced taxation from energy saving). It is strategic in nature. **H6** – As a result of an extreme event impact, FM can identify the overall risk (qualitative risk screening), which becomes a basis for considering climate change into risk assessment. Thus the adaptation process is reactive instead of planned.	**V6)** Mitigation measure in place. **V7)** Drivers for mitigation action. **V8)** Extreme event impact. **V9)** Level of risk identified due to climate change impacts. **V10)** Preparedness in addressing adaptation.

Alongside these primary derived variables, other variables were included for achieving a comprehensive questionnaire. The variables thus derived were constituted in both open and closed questions, taking the form of dichotomous, multiple choice, Likert and rating scale. A list of the variables and their typology (e.g. dichotomous, continuous etc.) is set out below in Table 15.

Table 15: Types of variables

Variable	**Type**
1) Business sector of organisation	Multiple choice
2) Type of organisation	Multiple choice
3) Post of respondent within organisation	Multiple choice
4) Professional Institution Membership	Multiple choice
5) Perceived awareness and knowledge on climate change	Likert scale – ranked
6) Perception about climate change	Likert scale – ranked
7) Approach to climate change (strategic and operational action)	Multiple choice
8) Extreme-event experience	Dichotomous
9) Considering future climate change	Dichotomous
10) Considering climate change in risk assessment	Dichotomous
11) Predicted level of impact of climate change	Likert scale – ranked
12) Approach towards adaptation	Multiple choice
13) FM strategic approach to mitigation	Dichotomous
14) Mitigation measures	Multiple choice
15) Drivers for mitigation	Multiple choice
16) Awareness of climate change initiatives	Multiple choice
17) Financial driver for mitigation	Dichotomous
18) Environmental inclination	Likert scale– ranked
19) Opinion about climate change and Government action	Likert scale – ranked

For the reasons described earlier in Chapter 3, the survey adopted an analytical questionnaire design whereby some of the aforementioned variables were also classified as experimental variables, dependent variables, controlled variables and uncontrolled variable. The questionnaire makes use of experimental (independent) variables, which are predictors, and dependent variables, which are variables being affected. This was primarily done to establish any correlation in existence amongst the variables.

6.2.1 Questionnaire planning

Given the considerable amount of guidance available from the literature by Oppenheim (1992), Creswell (2009), Bill (2008) and Dillman (2000), the basic principles of questionnaire planning were adapted from Oppenheim (1992) while the concept from Dillman (2000) of tailor-made design in the questionnaire was referred to for overall conceptualisation.

As per Oppenheim (1992), the general considerations for questionnaire planning should take account of:

- The types of data collection instruments – e.g. postal questionnaire, interviews or content analysis of records;
- Methods of approach to respondents once the sample has been selected – e.g. sponsorship, purpose of research, length of questionnaire, confidentiality and anonymity;
- A build-up of question sequences and modules within the questionnaire;
- The sequencing of questions within modules using a funnelling approach; and
- The types of question used – open vs. closed, and pre-coded or multiple-choice.

These principles were adhered to within the questionnaire planning for this research by keeping the total length of the questionnaire to a maximum of five pages since it was a web-based survey. The questions were divided into modules whereby each module addressed a specific topic. Section 1 collected general information about the individual and their role as a facilities manager. Section 2 collected organisation-specific information. Sections 3 and 4 comprised detailed questions relating to adaptation and mitigation measures taken to address climate change. Section 5 was composed of questions about the respondent's environmental inclination and their view on how Government policy is influencing climate change decision-making. The modules were sequenced in a way that the personal details and attitudinal statements appeared within the last module, which helped in avoiding confrontational aspects being revealed to the participant early on.

A funnelling approach in the question sequence within each module was considered whereby the module opens with a more general question and filters down to more specific questions. The opening question was asked to gather the participant's view on climate change at the end of the survey – done to make the survey easy to answer, with a majority of closed questions, and to give the participant an opportunity to add their own perspective on the issue.

Double-barrelled and hypothetical questions were avoided. Simple words were used, and acronyms were avoided except in one question.

Some of the concepts, such as awareness and knowledge of climate change, were difficult to assess. In these circumstances there were two sets of variables employed. A primary variable enquired about the subjective perceived awareness and knowledge about climate change, which was then associated with a secondary variable enquiring about awareness and involvement with various climate change initiatives. Thus the secondary variables revealed actual knowledge and awareness while the primary variable produced the subjective perceived view of the respondents. The combination of these two responses represented the gap between the perception and existing knowledge on aspects of climate change mitigation and adaptation. The application of this method also helped in negating the effect of the social desirability bias produced from asking direct questions on perceived subjective awareness and knowledge on the issue.

In order to gauge each participant's attitude and perception to the environment, an existing 'new environmental paradigm' (NEP) scale was used, the validity and reliability of which is been tested by Dunlap et al (2000). A set of four items were devised to enquire about participants' views on climate change. By using a set of items, the same construct was enquired about and instability arising from any one item rating was reduced. A copy of the final survey can be found in Appendix 9.

In addition to the foregoing, the concept of tailor-made design (TMD) by Dillman (2000) was referred to in the overall design of survey. As per Dillman (2000), the tailored-made design approach is based on the principle of social exchange. This principle within a questionnaire survey highlights the need for increasing perceived rewards for responding, a decrease in perceived cost, and promotion of trust that a beneficial outcome will be reached as a result of the survey. It is to be noted that the reward and cost are not related to economic exchange; rather, the exchanges are non-tangible in nature.

Dillman (2000) advocates increasing the perceived reward through promoting strong sponsorship and showing positive regard, which has also been prompted by Oppenheim (1992). This was achieved in the present questionnaire by providing an invitation from the research guide, who is a senior BIFM member, together with a short outline of the research, to participate in the survey while mentioning the scarce availability of such information at the time of the survey. The cost occurring to the participant in the form of time and resources involved in responding was kept to a minimum by using an online questionnaire and avoiding extensive questionnaire length. Respondents' trust in the survey was maintained, by assuring the participant of anonymity of the data provided and use of data for research purposes only. Later on, a short summary of result was provided to the respondents who had provided further personal details and agreement for any further interview at the end of the survey, and this too endorsed a sense of trust.

The questionnaire thus designed was first piloted internally with a team of colleagues to ensure that the design and instructions were easy to follow and the questionnaire was easy to navigate. Running a pilot scheme also ensured that the questions enquired about specific variables as intended. After that, a larger pilot amongst the targeted population was conducted, and the results gave some indication of response rates and issues that may be encountered in the full survey. This larger pilot is described in more detail in subsection 6.2.2.

6.2.2 The larger pilot survey

A pilot study was conducted among 231 participants who were randomly selected from the BIFM members' database. The sample survey was sent out between 14th May 2008 and 4th June 2008. A total of 21 responses were received and 25 e-mail addresses returned as 'not valid', blocked by the company server or 'respondent has left the company'. This gave a 9.1% response rate amongst those who received the survey. Although this response rate was low, considering that the full survey would be sent to all BIFM members (around 4,800), a similar response rate would result in approximately 440 completed returns and this was considered sufficient to validate the conceptual model. Respondents who could not complete the questionnaire online were provided with a printed version on request by post or fax.

The pilot survey confirmed that:

- Participants were comfortable with responding to the online questionnaire.
- The questionnaire was sent as an email attachment, which was blocked by some company systems, but this was resolved for the main survey by placing the questionnaire survey on the university server and creating an html link, which could was embedded in the e-mail invitation to complete the survey.
- The process of sending the survey, the return of responses and preparation for analysis was completed in 15–20 days; and the responses received could be directly imported into survey software, which made it easy for detailed analysis and for creating basic tables and charts for reports.

The pilot survey was analysed to establish:

- Completeness and robustness of the responses.
- The demographics of those completing the questionnaire in comparison with the target audience.
- Whether any multiple responses (same respondent answering the questionnaire twice) were received.
- Whether there were enough respondents agreeing to a follow-up interview.

The analysis revealed that 95% of respondents were BIFM members, confirming that the targeted population had been reached. Of the total responses, 15% of respondents were executive managers (responsible for strategy), 30% were senior managers, 30% were FM managers, and the remaining 25% were responsible for a mix of FM or other management activities. Responses were from a wide range of organisation types (commercial, educational, industrial, consultancies etc.), which again supported the view that the survey had reached its target audience. There were no multiple responses identified. A total of 35% of respondents agreed to be contacted for a further interview if required.

Most of the responses were complete The questionnaire was checked again for any discrepancy and wording of the questions were altered wherever required.

Furthermore, the new ecological paradigm (NEP) (Dunlap et.al 2000) scale for measuring environmental inclination was chosen due to its established use in environmental behaviour studies (Edgell and Nowell 1989, Poortinga et al 2004). The NEP scale included in the survey was made up of 8 items compared to the original 15 items. This was due to the constraints on the length of the online questionnaire. The pilot survey revealed an imbalance of the shorter version of the NEP scale included in the survey (5 positive and 3 negative statements) . This was rectified by including a more balanced selection of standard items from the NEP scale in the final survey (4 negative and 4 positive statements). The original NEP scale included the following statements, where respondents scored their agreement on scale of 1=strongly agree through to 5=strongly disagree:

a) The balance of nature is very delicate and easily upset.
b) When humans interfere with nature, it often has disastrous consequences.
c) Mankind was created to rule over the rest of nature.
d) The earth is like a spaceship, with only limited room and resources.
e) There are limits to growth beyond which our industrialised society cannot expand.
f) Humans have the right to modify the natural environment to suit their needs.
g) Human ingenuity will ensure that we do not make the Earth uninhabitable.
h) If things continue on their present course, we will soon experience a major ecological catastrophe.

Statement (e) was changed in the full survey to a more balanced statement, reading: *"The so-called 'ecological crisis' facing humankind has been greatly exaggerated."* This made the scale more balanced.

As a consequence of the pilot study, the research author was confident that the full survey could be analysed in terms of the primary research questions and also to identify any emerging patterns in responses within the wider population (e.g. differences between sectors or responses from individuals at different levels within organisations).

The pilot study responses were also analysed for the suitability of a range of statistical techniques by determining their distribution curves. These revealed that much of the data received followed non-normal distribution. This was attributed to the nature of the inquiry and questionnaire, which was not possible to alter anymore. For this reason the required analysis was to be carried out using non-parametric statistical tests (e.g. the Mann–Whitney U test and Spearman's correlation coefficient). This was because these statistical tests do not follow the strict data distribution characteristics or assumptions to analyse the quantitative relationships between the variables.

6.3 Final survey response and selected statistical analysis

The main survey found in Appendix 9 was distributed online between 16th June and 10th Aug 2008. An invitation email containing a letter of introduction and a link to the online questionnaire was sent to every member of the BIFM, requesting their assistance with the survey.

The questionnaire was sent to 4,827 members individually. A total of 470 e-mails were returned as either 'not a valid email address' or because the intended recipient had left the company or was on extended leave. Thus the effective population size was 4,357. A reminder was sent to any participants who were away from their office (i.e. who returned an auto reply e-mail). At the end of this exercise, 479 responses had been received (of which six were largely incomplete). Thus a total of 473 completed responses were included in the full analysis. This represents a response rate of 10.8% which is again similar to – in fact slightly higher than – that achieved in the pilot study.

6.3.1 Data collection and transformation

The questionnaire responses were imported to the SNAP software where they were automatically decoded. In order to carry out any analysis, the data had to be exported to EXCEL. The process of exporting data from SNAP to EXCEL automatically assigned separate columns to individual variables. An initial check revealed missing data, which was given the value of 0.00 in EXCEL.

Standard SPSS (statistical package for social science) software was used for statistical analysis. A short description of the data preparation undertaken can be found in Chapter 3. The following stages describe the process followed to create an SPSS database file as directed by Pallant (2005) and Field (2005):

- **Preparing a codebook –** A codebook is maintained which comprises of all the named variables and the coding given to every value of those variables.

- **Transferring data from EXCEL to SPSS –** The data from EXCEL was transferred to SPSS and the values were coded as per the predefined coding in the codebook. For instance, a dichotomous variable was assigned coding as 2= yes, 1=no and 0=don't know.

- **Entering the variable and coding it in SPSS –** Each variable was then entered into SPSS, where it is named, classified and coding labels entered.

- **Transforming data –** The ordinal data gathered had to be transformed in SPSS. In other words, the scale scores were reversed for SPSS calculation and correlation whereby for some scale the score 1= strongly agree and 5= strongly disagree were transformed to be reverse-coded as 5 = strongly agree and 1 = strongly disagree.

Any missing value was not coded as it was decided that the cases with missing values would not be included in any correlation or other statistical test.

6.3.2 Selected statistical analysis techniques

Statistical methods were adopted to analyse the data gathered from the survey. Huntsberger and Billingsley (1989) define 'statistics' as *"the science of collecting, analysing, and interpreting quantitative data in such a way that the reliability of the conclusions can be evaluated in an objective way"*. Although statistics is just a mathematical process and the results gained through the statistical analysis cannot be regarded as complete, it helps in providing evidence for the strength of relationship between the defined variables, which are hypothesised by observing real-world situations or theoretical propositions.

A statistical test helps in defining the overall character of the targeted population (through mean, median, mode, standard deviation etc.). It can also help in establishing any relationship amongst different characteristics of the population and, finally, it can be used to formulate a causal (cause and effect) relationship model. In statistics, correlation differs from regression as the first measures the association between variables while the other predicts one variable on the basis of the (one) other (or many others) (Tabachnick and Fidell 1983).

Both univariate and multivariate analyses have been used to describe the data obtained for this research. Univariate analysis helped in establishing the basic frequency, mean and summation score specifically for the ordinal data. A Lilliefors test was undertaken to determine the overall distribution of the data, which did not follow a normal distribution in all cases. Statistical transformation of data was possible to generate a normally distributed set of results, but it was conceived that the data should be used in its original form and a non-parametric test adopted which was free from the normal distribution rules and assumptions. Thus the chi-square test, the Mann-Whitney U test and the Wilcoxon signed rank test were each implemented to find any difference amongst the various sectors and types of organisation (e.g. SMEs and multinationals), while the and Spearman's rank order correlation were implemented for establishing any correlations and their strength. This helped in establishing the hypothesised relationship among the variables.

Multivariate analysis was adopted for undertaking logistic regression in a second stage of data analysis. Regression analysis allows the establishment of sophisticated exploration of the interrelationship between variables through sets of statistical techniques (Pallant 2005; Tabachnick and Fidell 1983). Establishing these relationships helped in outlining and validating the adaptation process as observed during the participatory study. The adaptation process was found to be in line with the concepts identified in adaptation literature. Amongst the various types of regression analysis available (hierarchical, stepwise etc.), standard multiple (logistic) regression was chosen. The theoretical and practical limitations of undertaking regression analysis are mentioned in Chapter 3.

6.4 Chapter summary

This chapter presents the second stage of the mixed-method approach adopted for the research study, i.e. the quantitative questionnaire survey (in outline). The questionnaire survey was intended to validate the concepts and findings revealed through the qualitative participatory study and implementation of the UKCIP framework. BIFM members were selected as a targeted population since this represented the largest population of facilities managers from various sectors all over the United Kingdom. Owing to the availability of only the e-mail address of BIFM members, the questionnaire was required to be web-based. SNAP software was used for constructing and distributing the web-based survey.

The participatory study findings were used for operationalised statements and workable variables to be tested, while the basic principles of questionnaire design outlined by Oppenheim (1992) and Dillman (2000) were adhered to for setting and wording the questions. The survey was first piloted internally with a team of colleagues prior to carrying out a larger pilot amongst the targeted population. This had ensured the appropriateness of the visual layout and the setting of the web-based questionnaire. A successful pilot was carried out, which pointed towards a few questions not attaining their intended outcomes, so these were altered before making the questionnaire available online to the wider population.

In total, 473 responses were recorded, representing a response rate of 10.8%. The data received was recorded and transformed into the statistical package SPSS for further analysis and for validation of the operationalised hypothesis. The selected statistical analyses included non-parametric tests due to non-normal data distributions. The basic frequency results, correlations and logistic regressions form the main content of the next two chapters.

Chapter 7: Questionnaire analysis and results

Following the data gathering and transformation stage, this chapter presents the results obtained through analysis of the questionnaire responses (see Appendix 9 for the questionnaire used). Initial section 7.1 provides the basic frequency counts with the help of charts and tables. It also offers differentiation found between the public and private sectors and amongst the various levels of commercial organisation (such as SMEs and multinationals). Section 7.2 explores the correlations amongst the variables to provide evidence for validation of the hypothesis mentioned in Chapter 6. Final section 7.3 summarises the overall results.

7.1 Basic frequency counts and statistical analyses

In order to determine the specific attributes of the responses received, basic frequency counts in SPSS were generated while mean, mode and standard deviation were calculated for ordinal-scale data. The cases with no response to the specific question were deleted from the frequency analysis. As a result and in spite of receiving 473 questionnaire responses, individual question frequency counts differed.

The basic count of all 22 questions has been divided in five sections. Section 1 presents the responses differentiated in terms of sector, organisation, respondents' positions and whether they had institutional membership. Section 2 reports on the perceived awareness and knowledge indicated by the participants, with an outline of the organisational approach and specific action for climate change. Section 3 mentions the attributes related to adaptation where the data on the experience of extreme events, impacts and consideration of future impacts is presented. The subsequent sections 4 and 5 outline the characteristics of the mitigation measures and participants' opinions on climate change.

The analysis in some cases is presented considering the differences between the public and private sectors, while some question responses are differentiated by considering various levels of organisation (e.g. SME and multinationals).

7.1.1 Questionnaire section 1 – General information

The questions asked in this section were intended to gather general information about each respondent's post within their organisation, the sector within which the organisation operated, and the size of the organisation, confirming the targeted responses. Data was also gathered on whether the respondents belonged to an FM institutional body.

Table 16 and Figure 13 show that from a total of 473 responses there were almost equal (37% and 38%) levels of response from public and private sector organisations respectively. indicate that 1.9%, 0.8%, 7.2% and 10.6% of responses were (respectively) from cross-sectoral, recreational, FM consultancy and FM contractor organisations.

Table 16: Sectoral responses

N	Valid	473
	Missing	0

Categories		**Frequency**	**Percent**	**Valid Percentage %**
Valid	Public sector	176	37.2	37.2
	Private sector	182	38.5	38.5
	Cross sectoral	9	1.9	1.9
	Recreational	4	0.8	0.8
	FM consultant	34	7.2	7.2
	FM contractors	50	10.6	10.6
	Unclassified	18	3.8	3.8
	Total	**473**	**100.0**	**100.0**

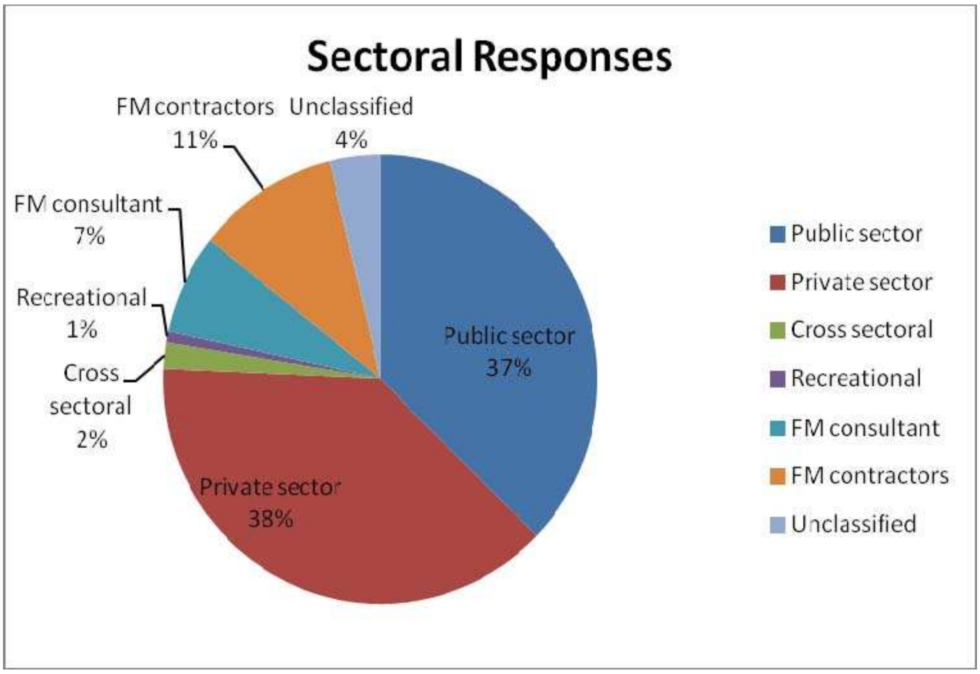


Fig 13: Pie chart of sectoral responses

The public sector further included 5% of respondents from the health sector, 12% from education (schools and university) and 15% from local authorities or independent government organisations, while another 5% of organisations did not indicate the nature of their organisation and were classified as public as a result of other information provided in their response. The private sector consisted of 22% as commercial organisations, 3% as industrial, 3% as retail, 2% as utilities and 8% of organisations which did not indicate the nature of organisation but were classified as private from the other information provided in their responses.

The results show that bias towards any one business sector is avoided and a total of 75% (38% private and 37% public) of responses could to be used for further analysis across the sectors. This also gave an additional advantage for further analysis, where public and private sector differences in perception and action taken for climate change could be considered.

The respondents were asked then to indicate the level of organisation they belonged to – i.e. SME, UK-based larger corporations, or multinational. In addition, they were asked to mention the number of employee their organisation retains. By combining the response from these two questions, the responses from different levels of organisations were calculated.

For ease of analysis the responses were differentiated into six categories dependent on numbers of employees, as presented in Table 17.

Table 17: Derived organisational categories

Group no.	**No. of employees**
1 (SME)	1–250
2	251–500
3	501–2,000
4	2,001–3,500
5	3,501–5,000
6 (multinational)	5,001+

In total, 396 (83.7%) participants responded to these questions. The results showed that 22% and 25.3% of organisations were SMEs (less than 250 employees) and multinationals (more than 5,000 employees) respectively. The larger corporate sector here is divided into four categories where equal levels of response (11.1%) were from organisations with 251–500 employees and 2,001–3,500 employees while 23.5% of responses were from organisations employing between 501 and 2,000 employees and another 7.1% from organisations who employed between 3,501 to 5,000 employees (see Table 18 and Figure 14).

Table 18: Organisational response

N	Valid	396
	Missing	77

Categories		**Frequency**	**Percentage**	**Valid Percentage %**
Valid	1	87	18.4	22.0
	2	44	9.3	11.1
	3	93	19.7	23.5
	4	44	9.3	11.1
	5	28	5.9	7.1
	6	100	21.1	25.3
	Total	396	83.7	100.0
Missing	System	77	16.3	
Total		473	100.0	

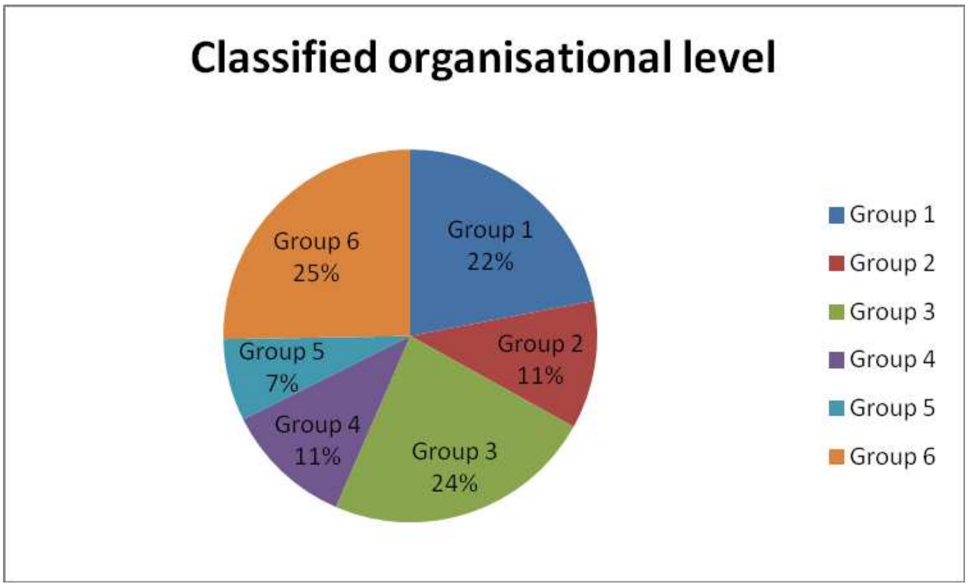


Figure 14: Classified organisational-level responses

The question enquiring about the post held by each participant was intended to determine the respondent's current role responsibility with respect to facilities management in the organisation. The question was also helpful in confirming the targeted population of strategic- and managerial-level facilities personnel. Table 19 and Figure 15 represent the results.

Table 19: FM official post categories

N	Valid	473
	Missing	6

Categories		Frequency	Percent	Valid Percentage %
Valid	Executive FM	126	26.6	27.0
	Senior FM	205	43.3	43.9
	FM manager	84	17.8	18.0
	Operational FM	29	6.1	6.2
	Other FM related posts	23	4.9	4.9
	Total	467	98.7	100.0
Missing	System	6	1.3	
Total		473	100.0	

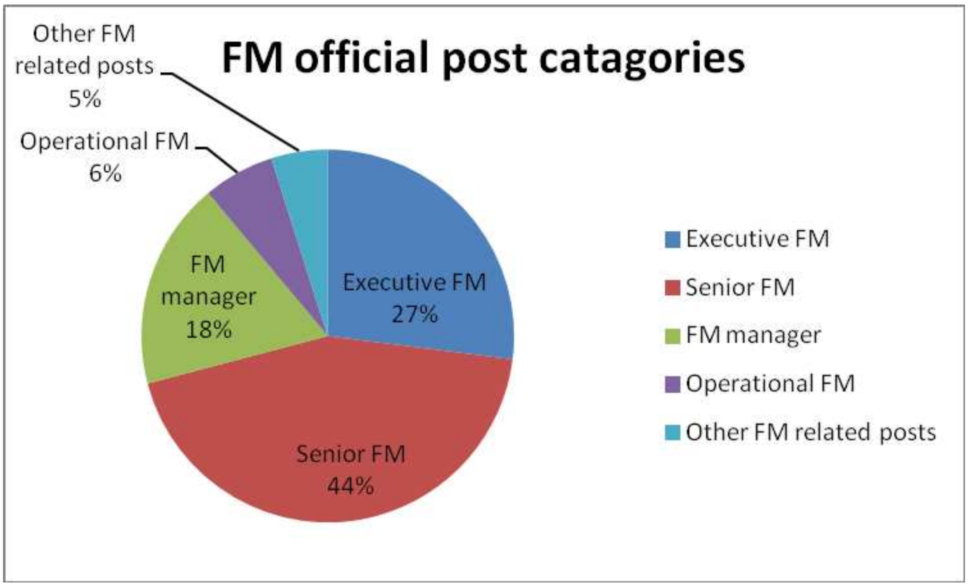


Fig 15: Category responses for official FM post

Most respondents (43.9%) were senior facilities managers responsible for a building or group of buildings, followed by 27% as executive managers (responsible for strategy) – confirming that the targeted population has been reached (i.e. the questionnaire reached people who were responsible for considering and taking decision about addressing future climate-change impacts or whose perception and action could affect the way facilities managers address climate change). Other responses included 18% from FM managers (responsible for specific FM services or maintenance) and 6.2% from operational facilities managers. Other (4.9%) responses were from different FM-related roles (e.g. consultant, FM project manager).

Enquiry about institutional membership was made to confirm that the respondents belonged to an FM body and whether the institutional membership influenced participants' insight into climate change issues (in turn affecting their attitude and action on climate change).

The results in Table 20 and Figure 16 confirmed that the target population group of BIFM members was reached as 81.4% of the respondents were BIFM/IFMA or EuroFM members, while 9.5% respondents were CIBSE/CIOB/RICS members in addition to being BIFM/IFMA/EuroFM members. A further 8% had combination of CIBSE and one of the FM institute membership while only 1.1% respondents had other membership.

Table 20: Institutional FM membership of respondents

N	Valid	451
	Missing	22

Categories		**Frequency**	**Percent**	**Valid Percentage %**
Valid	BIFM/IFMA/Euro FM	367	77.6	81.4
	FM member+CIBSE member	36	7.6	8.0
Missing	FM member+other membership	43	9.1	9.5
	Other membership	5	1.1	1.1
	Total	451	95.3	100.0
	System	22	4.7	
Total		473	100.0	

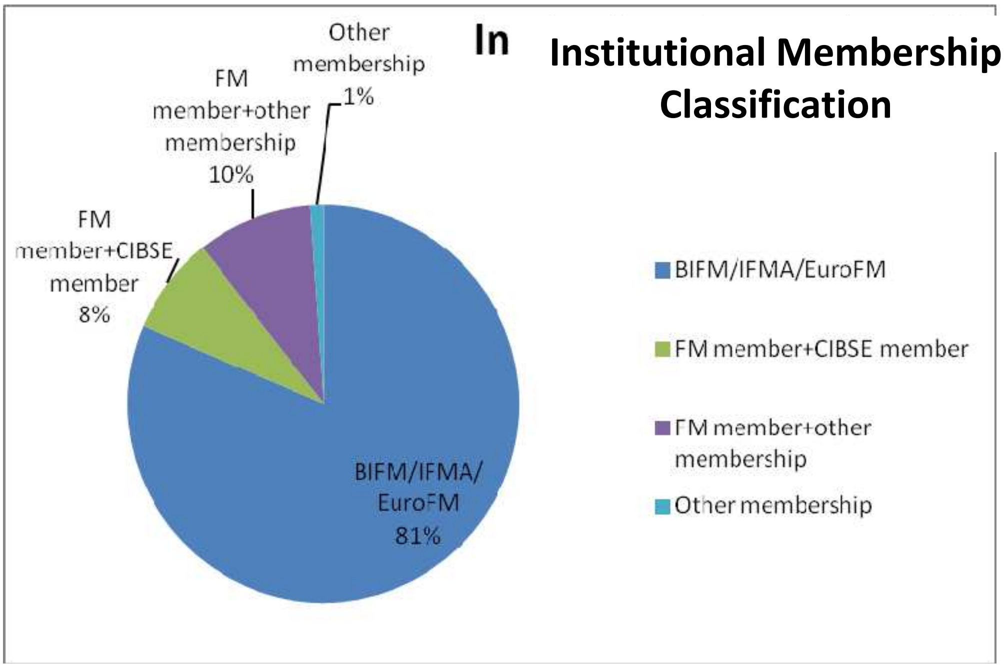


Fig 16: Classified responses for professional institution membership

In summary, the frequency analysis for section 1 of the questionnaire confirmed that the survey was answered by the targeted population where an almost equal number of facilities managers from the public and private sectors responded. These responses were received from different levels of organisation and were almost equally distributed across various organisational levels (SMEs, medium-sizes corporations and multinationals). Most of the respondents were senior facilities managers or executive managers, who are more likely to be involved in strategic FM decision making and who thus would have more of a say in actions for climate change adaptation and mitigation within FM operations.

7.1.2 Questionnaire section 2 – Organisational response

The questions in this section were intended to generate responses about respondents' subjective climate-change-related awareness and knowledge along with their organisation's general approach to climate change, since these subjective aspects were observed with the participants involved in the participative study. Obtaining views was done by combining the answers from two tiered questions whereby, first, the perceived knowledge and awareness was measured on an ordinal scale and then, as a second tier, questions (in later sections) were asked about their actual knowledge and involvement with adaptation and mitigation initiatives.

Much of the questioning in this section used an ordinal scale and thus the frequency count was represented using mean (average count from data), median, standard deviation (separation between the data count) and mode (reoccurring data count). The frequency counts were calculated for: (a) the perceived individual, senior-management and junior-management awareness and knowledge on climate change impacts; (b) the overall perception of climate change as a risk or opportunity; and (c) each specific organisation's approach to climate change.

The questions on the topic of perceived awareness and knowledge about climate change had been asked of FM personnel, including their junior and senior management, with regard to awareness and knowledge of the impact of climate change. In total 470 participants from 473 replied, with just a few failing to answer the questions. The analysis shows mean = 4.06 (out of 5) and SD= 0.96 for personal climate change impact knowledge, which tells us that facilities managers perceive themselves as knowledgeable about climate change impacts.

As shown in Tables 21 and 22 and Figure 17, the participants reported their junior FM manager's knowledge about impact of climate change with mean = 3.28 and SD = 1.09, which means that the junior FM is perceived to be neither completely aware nor unaware about climate change impact. Senior level management was perceived to be knowledgeable with calculated mean = 3.59 and SD = 1.21. Since the question enquired about participants' *perceived* knowledge and awareness, the data was found to be slightly positively skewed. As mentioned above, it would be revealed in a later analysis that this perceived knowledge of the impacts of climate change relates to mitigation initiatives rather than adaptation.

Table 21: FM junior and senior manager knowledge and awareness, as perceived by respondents (statistical results)

		Climate change awareness in senior management	Climate change awareness in junior management	Climate change impact knowledge in senior management	Climate change impact knowledge in junior management	Personal climate change awareness	Personal climate change impact knowledge
N	Valid	470	470	470	461	470	464
	Missing	3	3	3	12	3	9
Mean		3.84	3.43	3.59	3.28	4.20	4.06
Median		4.00	3.50	4.00	3.00	4.00	4.00
Mode		4	3	4	3	5	4
Std. deviation		1.123	1.094	1.211	1.099	.931	0.963
Variance		1.262	1.197	1.466	1.207	.867	0.927
Skewness		-1.096	-0.728	-0.887	-0.616	-1.596	-1.268
Std. error of skewness		0.113	0.113	0.113	0.114	0.113	0.113
Kurtosis		1.191	0.810	0.514	0.647	3.327	2.118
Std. error of kurtosis		0.225	0.225	.225	0.227	0.225	0.226
Range		5	5	5	5	5	5
Minimum		0	0	0	0	0	0
Maximum		5	5	5	5	5	5

Table 22: FM junior and senior manager's knowledge and awareness as indicated by respondents (frequency count)

Knowledge of climate change impact	Not knowledgeable	Less knowledgeable	Not aware, not unaware	Knowledgeable	Very knowledgeable	Don't know	Total	Missing	Total
Senior FM managers	11	63	95	175	113	13	470	3	473
Junior FM managers	12	67	169	145	56	12	461	12	473
Respondents in person	7	21	67	197	169	3	464	9	473

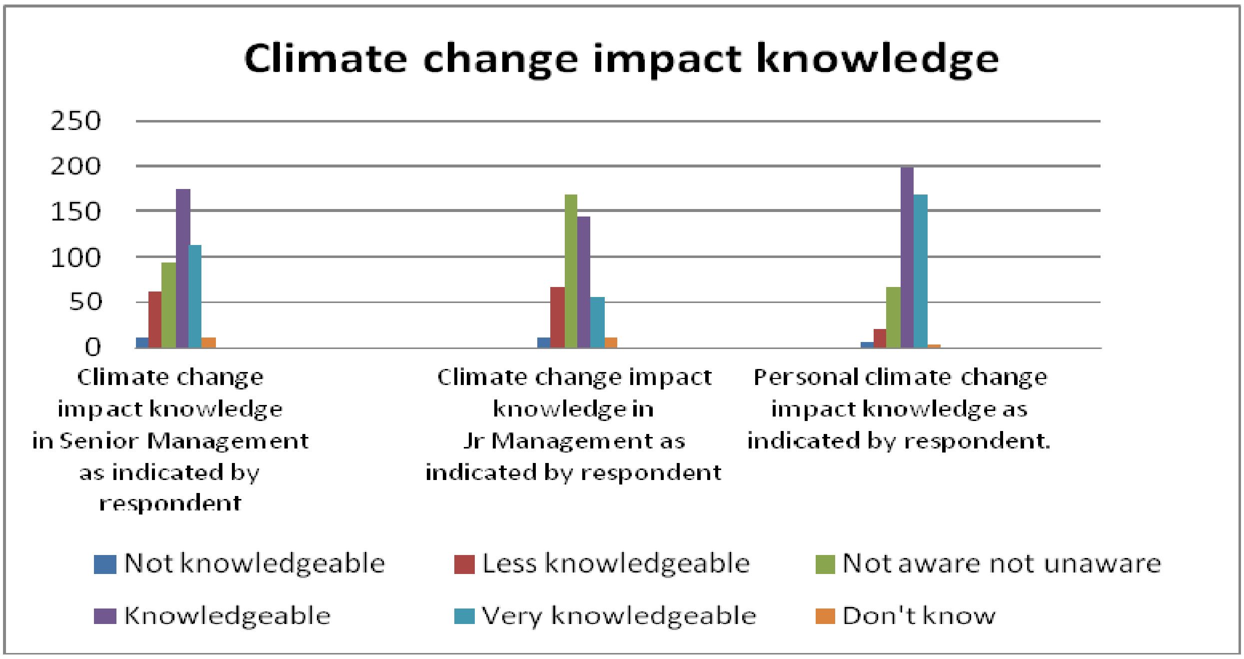


Figure 17: Climate change impact knowledge in senior and junior managers

O'Connor et al (1999) argue that risk perception shares a common ground with knowledge, and knowledge can initiate action even in cases of a weak signal. This has also been supported by Dessai et al (2004) suggesting that the danger which constitutes the *"individual or collective experience or perception of insecurity (risk) is an important aspect to be noted in climate change responses"*. In addition, Lorenzoni et al (2005) point that perceived long-term but too distant climate changes and an absence of an immediate affect and solution may affect the implementation of proactive responses to climate change, indicating that the existence of an immediate effect and solution may induce perceived risk and thereby initiate thinking about the long-term approach to distant climate changes. This was evident in the participatory organisation as the immediate experience of extreme weather events and a resultant significant financial loss had initiated action for addressing such events and formulating an opinion that these extreme events would probably increase in the future as a result of climate change (thus posing more risk to the organisation's properties and operations).

A question was therefore asked about whether the respondents viewed climate change as a risk, an opportunity or a factor affecting their service delivery. The responses were once again measured on the ordinal scale. The results are represented in Tables 23 and 24 and Figure 18, and they indicate that the FM community neither agrees nor disagrees (mean=3.39, SD=1.1) that climate change represents a risk to their organisation. This implies that the FM community is not certain of the precise climate change impacts which could represent a risk to their organisation and function – in accordance with other evidence found in the literature (O'Connor et al 1999; Morton et al 2011).

Table 23: Perception of climate change amongst FM respondents (statistical results)

		Climate change perceived as risk	Climate change perceived as affecting FM services	Climate change perceived as opportunity
N	Valid	466	470	464
	Missing	7	3	9
Mean		3.39	3.93	3.98
Median		3.00	4.00	4.00
Mode		4	4	4
Std. deviation		1.100	0.887	1.048
Skewness		-0.386	-1.134	-1.260
Std. error of skewness		0.113	0.113	0.113
Kurtosis		-0.266	2.280	1.654
Std. error of kurtosis		0.226	0.225	0.226
Minimum		0	0	0
Maximum		5	5	5
Sum		1579	1847	1847

Table 24: Perception of climate change amongst FM respondents (frequency counts)

	Don't know	**Strongly disagree**	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**	**Agree + St. agree**	**Total**	**Missing**	**Total resp.**
Climate change perceived as a risk	3	20	72	145	150	76	226	466	7	473
Climate change perceived as affecting FM services	3	3	27	73	249	115	364	470	3	473
Climate change perceived as an opportunity	3	16	21	70	191	163	354	464	9	473
	%	%	%	%	%	%	%	%		
Climate change perceived as a risk	0.6	4.3	15.5	31.1	32.2	16.3	48.4	100		
Climate change perceived as affecting FM services	0.6	0.6	5.7	15.5	53.0	24.5	77.4	100		
Climate change perceived as an opportunity	0.6	3.4	4.5	15.1	41.2	35.1	76.2	100		

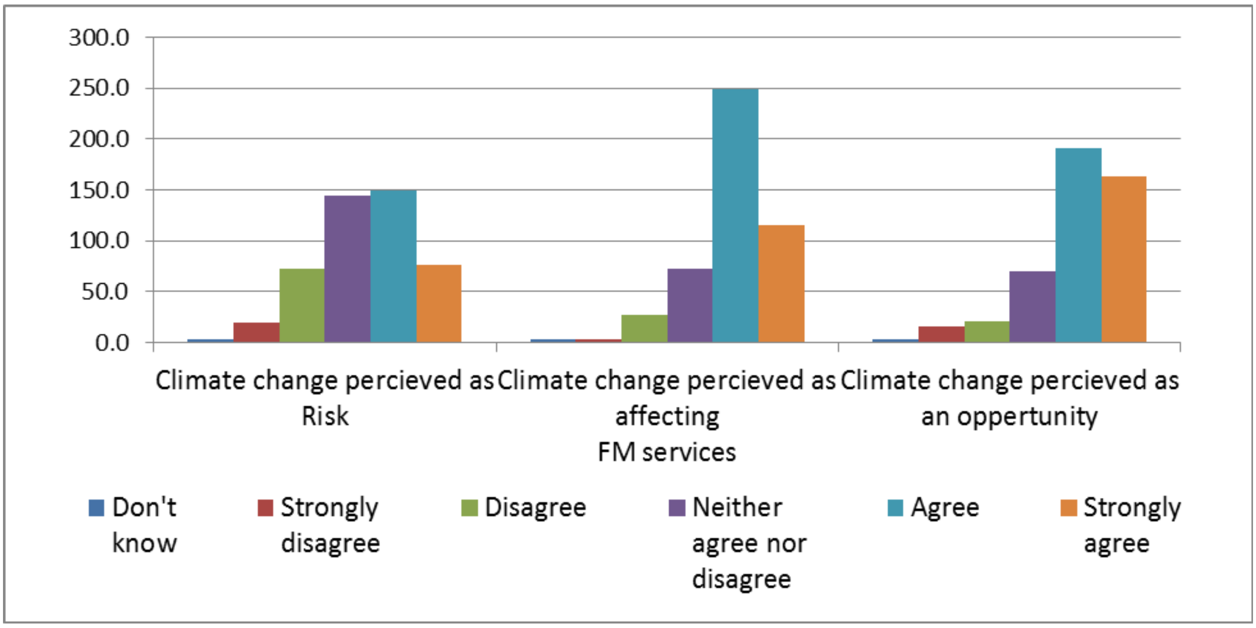


Figure 18: Perception of climate change as risk or opportunity amongst respondents

In contrast, facilities managers agree that climate change will affect the way FM provides services (mean=3.98, SD=0.8) and also that climate change is an opportunity to develop new products (mean=3.93, SD=1.04). Thus it could be said that facilities managers do not completely perceive climate change as a future threat but as a factor that will change the way they provide FM services to their organisation, with possibility of developing new products.

With regard to the overall approach taken to climate change by participants and their organisations, the agenda for sustainability and energy efficiency has been on the FM horizon since the emergence of the Burtland report in 1987. The approach to climate change and specifically addressing CO_2 reduction has been largely associated with a sustainability strategy within many organisations.

It was hypothesised from the literature and participatory study organisation overview that the overall organisational approach taken for addressing climate change will play a part in determining the future action for climate change adaptation and mitigation. In order to get an overall view of different organisations' approaches, a multiple-choice question was asked. The answers were categorised into six, and the detailed results could be found in Table 25 and Figure 19.

Table 25: Categories derived for organisations' approaches to climate change

Derived Categories	Number of responses
Operational and other steps	8
Ad-hoc approach	11
Responses indicating orgs have not addressed climate change while taking an ad-hoc approach	13
Strategic steps	17
Responses indicating the taking of substantial action in spite of undertaking some strategic and operational measures	22
Taken all measures	27

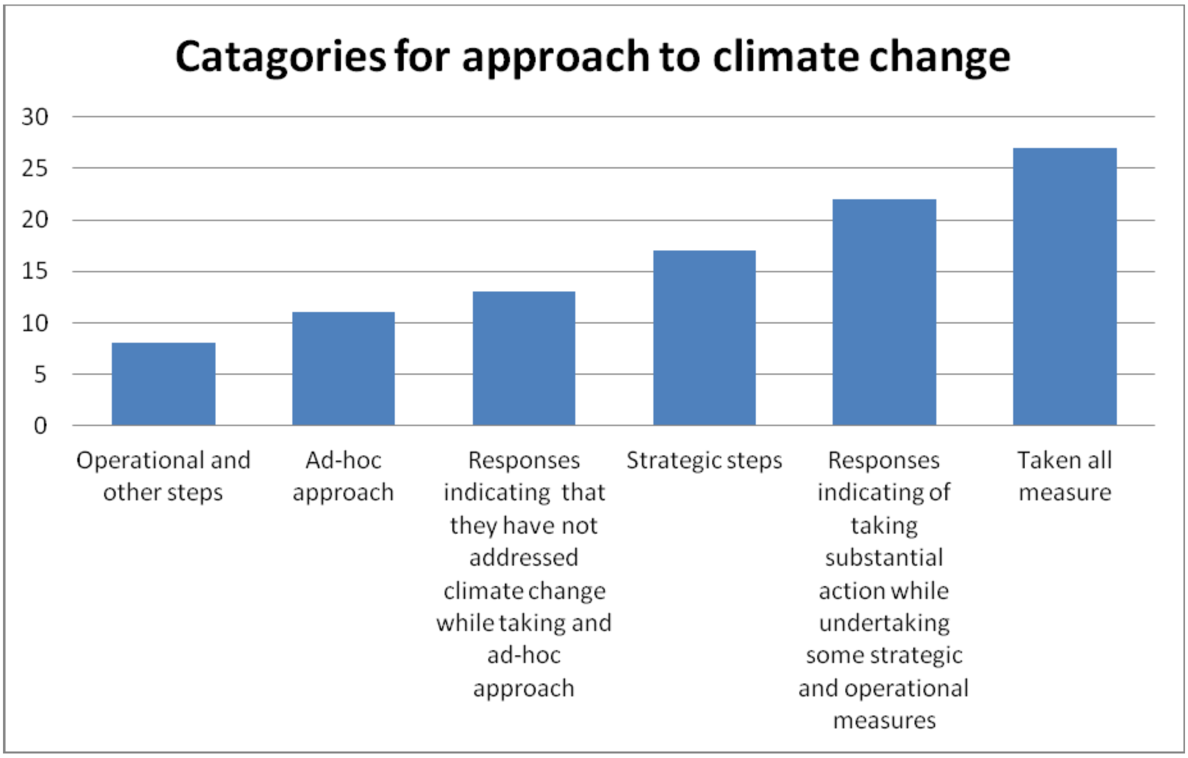


Figure 19: Organisational approaches to climate change

In total 465 (98%) participants responded to the questions on this topic. From these respondents 27% had taken operational, strategic and other measures such as training staff and appointing a responsible person for climate change action, while 17% and 8% of facilities managers had respectively taken strategic and operational steps. Another 22%, in spite of taking some operational or strategic steps, indicated that they were yet ready to take effective measures. And 11% had, in addition to identifying senior/junior managers with the responsibility of climate change action, had taken measures such as providing training to staff and commissioning external consultants. The remaining 13% who responded fully on this topic, in spite of taking measures, suggested that they had not yet addressed climate change within their organisation as the actions had not formally been defined as strategic or operational.

From the above result it could be said that majority (8%+11%+17%+27%=63%) of facilities managers and organisations are taking strategic, operational or other measures required for climate change, with most suggesting they have taken strategic measures. This tells us that climate change is considered to be a strategic issue by organisations and their FM managers. On the other hand, (13%+22%=35%) of organisations had not taken measures or suggested that they were yet to take measures for climate change.

It seems that a strategic organisational approach addressing climate change is essential for facilities managers to consider any further action on the grounds and that any action for climate change mitigation is counted as ad-hoc if not supported by strategic decision making. This follows the argument made for taking forward a sustainability agenda, where Elmualim et al (2010) observe the lack of commitment from senior management as a barrier to sustainable FM practices.

A qualitative question was asked to ascertain the specific actions taken for addressing climate change. It was largely expected that these actions would be counted towards a reduction of CO_2 (mitigation action).

From a total of 473 respondents, 186 responded to the question (40% of population). The answers were screened and four basic categories (as shown in Figure 20) were formulated for further coding of the responses.

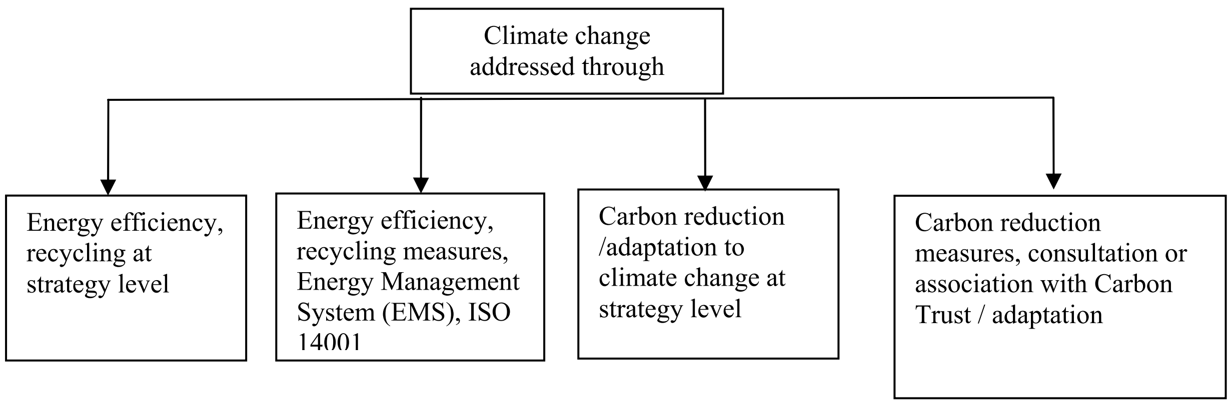


Figure 20: Coding categories for qualitative analysis

The results revealed that many of the respondents (29.0%) are involved in taking energy efficiency measures and 27.4% have CO_2 reduction at a strategic level. There are few organisations (9.7%) that have mentioned having taken reduction measures in consultation with the Carbon Trust, and another 10.2% have, in addition to taking their own energy-efficiency measures, at least initiated consultations with the Carbon Trust. The remainder (9.7%) [Q: have I edited this correctly?] had initiated carbon reduction at a strategic level, while only 1.6% of organisations indicated having carbon reduction action taken at a strategic level. A further 4.8% were not possible to code.

It was observed from the response classification decided upon that many organisations followed an incremental path towards addressing climate change, which could be explained with the help of following four conceptual levels:

1) Addressing a sustainability agenda at the strategic level
2) Working on recycling, Implementing EMS, and ISO accreditation.
3) Considering carbon reduction (due to legislation)
4) Taking additional operational measures for CO_2 reduction (on personal initiatives) or consulting with the Carbon Trust for taking practical measures.

Much of the level-4 activities were found to have been undertaken by multinationals for the obvious reason of resource availability and increased access to information and skills.

in summary, the analysis of section 2 affirms that, overall, facilities managers perceive their climate change awareness and knowledge to be adequate but at the same time they do not perceive climate change as presenting a risk to their facilities and service delivery. A general perception prevails that climate change will alter the way the services have been delivered up till now and may provide an opportunity to develop the delivery of new products. Although many of the organisations polled have been active in addressing climate change mitigation, many still remain lagging behind for implementing any kind of action.

There seems to be an incremental path followed while addressing climate change mitigation whereby the initial energy efficiency and recycling measures results in implementation of EMS standards, finally leading to strategic carbon-reduction targets and an achievement of these targets through ongoing external consultation (for instance with the Carbon Trust). The responses from many senior facilities managers note the existence of strategic targets and policy in strong operational measures.

7.1.3 Questionnaire section 3 – Adapting to climate change impacts

The questions in this section were intended to gather information about what the climate change impacts are that facilities managers predict they will have on their services, what stages they are at with respect to considering adaptation to the predicted impacts, and how far a response from facilities managers and their organisations is dependent upon experiencing a climate-related extreme event considering that such events will increase in their intensity and frequency with changing climate. The respondents were asked about their experience with climate-related extreme events and whether such events resulted in them considering future impacts in their routine disaster-recovery planning.

The initial frequency count showed that in total 212 (46%) participants had experienced climate-related events which affected their working environment (see Table 26 and Figure 21). Furthermore, 198 (93%) of the 212 participants mentioned measures taken for addressing the impact of future climate change (see Table 27 and Figure 22).

Table 26: Frequency count of participants who have experinced a climate-related extreme event

	Categories	Frequency	Percentage %
Valid (Experience of an event)	Yes	212	46.4
	No	234	51.2
	Don't Know	11	2.4
	Sub-total	*457*	*96.6*
Missing	System	16	3.4
Total		473	100

Table 27: Frequency count of participants who reported takeing measures for addressing climate-related extreme events

No reply on measures taken	Reply on measures taken	Total
275	198	473

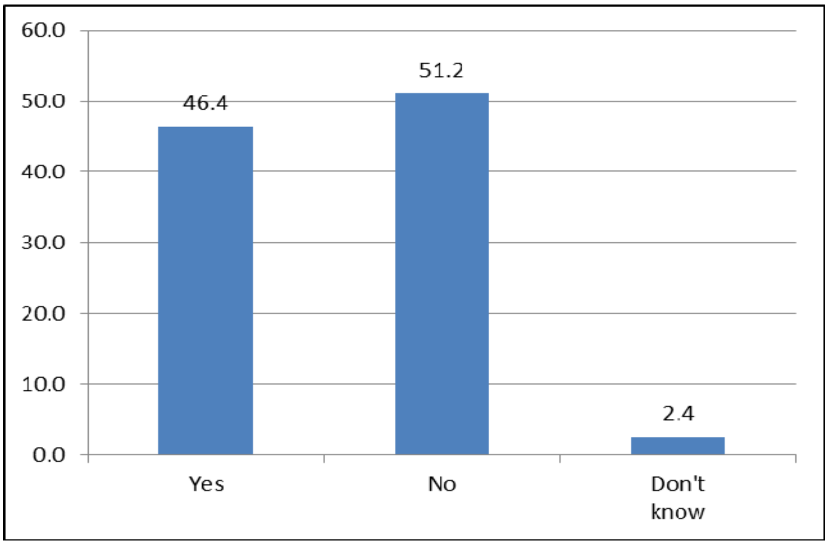


Figure 21: Experience of a climate-related extreme event reported by respondents

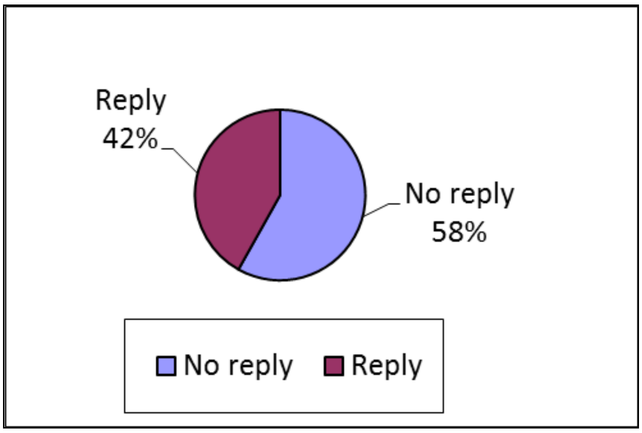


Figure 22: Responses on measures taken for limiting extreme weather-related damage

The comments and measures included an increase in temperature, leading to installation of air conditioning, chillers and fans; some had considered natural ventilation. Storm and high winds affected taller buildings and roofs, while heavy rains resulted in a need to clear drainage channels and higher maintenance cost of gutters and drainpipes. There were many mentioning the Midlands, Sheffield and Gloucestershire flooding, where staff could not reach the workplace and the basement had been flooded. In relation to flooding, many responses also mentioned measures such as installing drying pumps and stocking up on sandbags; some businesses had also considered moving vital equipment and functions from flood-affected areas. Power and fresh-water supplies could not be addressed as the local authorities and councils deal with these.

Even though these events cannot be directly attributed to climate change, the literature review has shown that experience of such events affects the decisions for organisations and individuals when considering future impacts. Thus, questions were asked in section 3 about whether these events affected an organisation's decision to consider climate change impacts for the future.

In total 212 (45% of respondents) were affected by one or the other climate-related events (mostly flooding, heavy rain, storm and overheating). A cross-tabulation was carried out between respondents affected by climate-related events and respondents' further consideration of similar future impacts, and Table 28 presents the statistical analysis. In total 211 participants responded to considering similar future impacts. The cross-tabulation revealed that 35 (16.5% of respondents) had indicated that the event did not result in them considering future impacts and 25 (11.8%) did not know whether they considered future impacts due to the occurrence of the event. In total 151 (71.2%) who indicated that they had been affected by a climate-related event agreed that the event had resulted in them considering potential future impacts.

Table 28: Cross-tabulation: experience of climate-related events vs. event resulting in considering future climate change effects

Case processing summary						
	Cases					
	Valid		Missing		Total	
	No.	Percent	No.	Percent	No.	Percent
Experience of Climate related events * Event resulting in considering climate change	412	87.1%	61	12.9%	473	100.0%

Cross-tabulation						
			Event resulting in considering climate change			Total
			Yes	No	Don't know	
Experience of climate related events	Yes	Count	151	35	25	211
		% within experience of climate related events	71.6%	16.6%	11.8%	100.0%
	No	Count	15	149	26	190
		% within climate related events	7.9%	78.4%	13.7%	100.0%
	Don't know	Count	1	2	8	11
		% within experience of climate related events	9.1%	18.2%	72.7%	100.0%
Total		Count	167	186	59	412
		% within experience of climate related events	40.5%	45.1%	14.3%	100.0%

On the question of including climate change impacts into disaster recover planning, a total of 253 (54%) of respondents out of 473 said that they do indeed consider climate change impacts within their disaster recovery planning and 162 (35%) respondents said they did not (see Table 29 and Figure 23).

Table 29: Frequency count of respondents reporting consideration of climate change impacts in their disaster recovery planning

	Categories	Frequency	Percentage %
Valid	Yes	253	54
	No	162	34
	Don't Know	49	10
	Total	464	98
Missing	System	9	1.9
Total		473	100

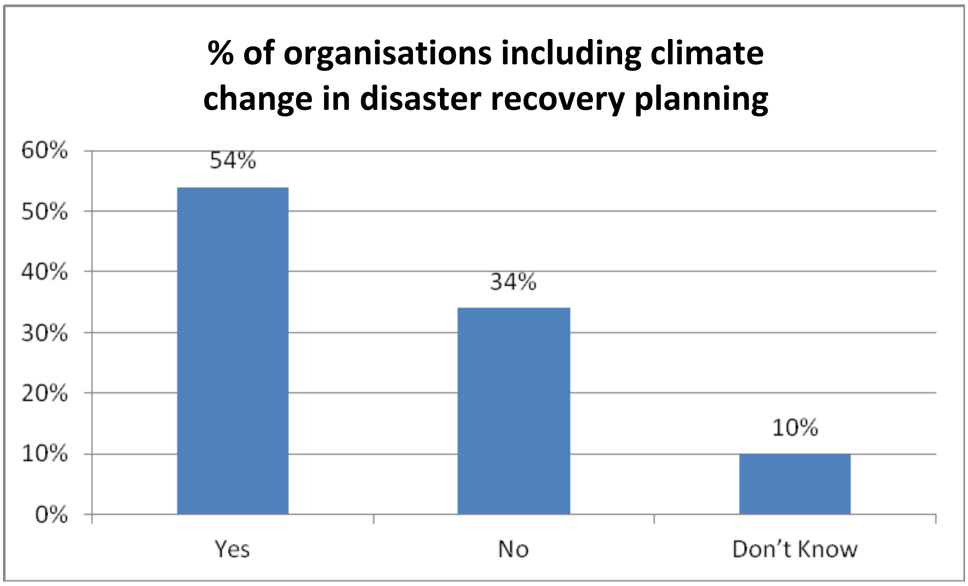


Figure 23 : Organisation response to including climate change in disaster recovery planning

The cross-tabulation in Table 30 between experience of climate-related extreme events and integrating future climate change impacts into routine disaster recovery planning informed that, from the 211 who had considered the impacts of climate change within their routine disaster recovery planning, 136 (64%) were affected by climate-related extreme weather events compared with 53 (25%) who did not. A further 22 (11% of participants) did not know which had occurred.

Table 30: Cross-tabulation for experience of climate-related extreme events and considering climate change within disaster recovery planning

Case processing summary

	Cases					
	Valid		Missing		Total	
	No.	Percent	No.	Percent	No.	Percent
Climate related events * Including climate change as part of disaster recovery planning	454	96.0%	19	4.0%	473	100.0%

Cross-tabulation

		Including climate change as part of disaster recovery planning			Total
		Yes	No	Don't know	
Climate related events	Yes	136	53	22	211
	No	107	103	22	232
	Don't know	7	3	1	11
Total		250	159	45	454

It could be said from the above figures that experiencing a climate-related event or extreme event is key for facilities managers to consider adaptation options and their inclusion into disaster recovery planning. Although it can not be concluded that absence of these experience will not result in any action, it is deduced that such events and disturbances to businesses work as a primary signal to initiate further adaptation measures, and their absence will result in late actions. This indicates a trend towards existing reactive measures.

The above findings are also in line with the literature-based evidence (Berkhout et al 2004) that experiencing an extreme event is a key to initiate adaptation processes and responses. The experience of such events along with the belief in climate change occurrence forms the initial stages of the overall adaptation process model outlined in later chapters, which is in confirmation with the model outlined by Grothmann and Patt (2005) and Berkhout et al (2004).

The respondents were asked to identify and rate the impacts of various climate change predictions on their properties and services. This was intended to analyse the participants' ability to screen and rate future impacts and assess the overall approach by their organisation towards addressing these identified impacts. The questions asked here in the questionnaire also attempted to check the overall organisational preparedness for addressing the classified impacts.

The participants were asked to rate the impacts on their property portfolio as significant, major, moderate, minor, or none of the preceding, in relation to the following:

- More winter rain;
- More frequent storms;
- Decreased snowfall;
- Increased winter temperature;
- More frequent and severe flooding;
- Sea level rise;
- More extremely hot summers;
- More summer droughts; and
- Changes in seasonality (e.g. an early spring).

It is to be noted that since the survey was distributed across cross section of businesses (ranging from SME to large corporates) the scale of significant or major impacts was in accordance with individual participant's view of the level of impact experienced. A qualitative explanation of the impact was mentioned by the participants in later question which helped assess and compare the level of impact experienced by individual respondents.

Given the reasonable amount of information on the known effects of a changing climate, the majority of facilities managers were able to identify the immediate impacts on their properties and premises and to categorize them as major, minor or none. It was observed that facilities managers as a respondent group were anticipating moderate-to-major impact on their buildings due to flooding, storm, hot summers and droughts (i.e. water shortages). Many managers were found to anticipate major impacts due to sea level rise, the reason being that their property is coastal-based. The impacts due to winter rain, winter temperature, storm and decreased snowfall were considered to be moderate to minor.

From a total of 310 (65%) of participants who anticipated significant or major future impact, 245 (79% of respondents) mentioned anticipated impacts which are related to: high energy cost and a demand for cooling; flooding risk to properties and staff's inability to reach work premises due to the flooding of the public infrastructure; and less fresh-water availability.

Table 31 shows that facilities managers overall are aware of the climate change impacts upon their organisation's function and services, and that they anticipate impacts ranging from minor to moderate. They anticipate moderate impact from more winter rain (mean=2.8, SD=1.1) frequent storm (mean=3.1, SD=1.16), frequent and severe flooding (mean=3.3, SD=1.3) and extremely hot summers and summer droughts (mean=3.6, SD=1.18) and (mean=3.1, SD=1.2) respectively).

Table 31: Respondents' awareness of impact of anticipated climate change

	Level of impact due to more winter rain	**More frequent storms**	**Decreased snowfall**	**Increased winter temp**	**Frequent and severe flooding**	**Sea level rise**	**More extremely hot summers**	**More summer droughts**	**Changes in seasonality**
	465	469	468	470	469	462	469	469	462
	8.0	4.0	5.0	3.0	4.0	11.0	4.0	4.0	11.0
Mean	2.8	3.1	1.4	2.4	3.3	2.4	3.6	3.1	2.1
Median	3.0	3.0	1.0	2.0	3.0	2.0	3.0	3.0	2.0
Mode	3.0	3.0	1.0	3.0	3.0	1.0	3.0	3.0	2.0
Std. Deviation	1.1	1.2	0.7	1.2	1.3	1.4	1.2	1.2	1.0
Variance	1.2	1.3	0.5	1.4	1.7	2.0	1.4	1.4	1.1
Skewness	0.5	0.3	1.5	0.7	-0.2	0.4	-0.2	0.2	0.6
Std. Error of Kurtosis	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Minimum	-0.1	-0.7	2.2	-0.1	-0.9	-0.9	-0.9	-0.5	0.4
Maximum	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

Table 32: Organisation response to impact of anticipated climate change

		Total	sig/major impact	comments made
Organisation size	SME	12	9	6
	UK corporate	77	49	44
	Multinational	90	58	49
	Total	179	116	99

Within the private sector, from a total of 12 SMEs nine identified the impacts as significant or major and a further six (50% of total SMEs) were able to specify the impacts in detail. From 77 UK corporates, 44 (57% of total UK corporate) identified and specified the impacts, while from 90 multinationals 58 identified the impacts as significant/major and a further 49 (54% of total multinationals) specified the impacts (see Table 32). The respondents were also able to specify the types of impact, which are summarised in Appendix 10.

In total 55% of 179 private-sector organisations could identify the impacts as significant and major and specified the impacts in detail. A total of 99 detailed impacts were mentioned, which were analysed by categorising them into three major categories: impacts to building components, impacts due to flooding and impacts due to overheating. These major categories were further populated with sub-categories identified from the responses (see Table 33). From 99 responses, 36 identified impacts due to flooding, 26 due to overheating and 10 due to impacts on building components. Another 20 responses mentioned a mix of impacts, including impacts due to overheating and flooding, damage to buildings, and impacts due to flooding and increased cost due to building damage and overheating (Table 34).

Table 33: Derived categories of identified impacts reported by respondents (analysed from qualitative responses)

Primary Categories	**Sub-categories identified from responses**
Flooding	Access to site
	Loss of building
	Relocation
	Insurance
	Car park and site flooding
Overheating	AC and Chillier Plant installation
	Increased energy bills
	Increased water use & water bills
	Overheating in server rooms
Building damage/repair	Increased maintenance cost
	Increased rainwater load for gutters and downpipes
	Roof damage

Table 34: Frequency count of identified impacts

Impacts identified	**Responses**
Impact due to flooding	36
Impact due to overheating	26
Impact on building component	10
Impact to building component and due to overheating	8
Impact due to flooding and overheating.	17
Impact due to flooding and to building component.	2
Total	99

Overall, this portrays a somewhat balanced view that the FM community was able to identify generalised impacts on their properties and functions.

The respondents were also asked about their organisation's approach to addressing the identified impacts. It was observed that, from 473 respondents, 352 (74%) responded to the question. Amongst them, only 13% indicated that they have measures in place, while almost same number (15%) indicated that they have prioritised the risk and that they are dealing with the important impacts (Table 35 and Figure 24). Another 23% were considering how to deal with the impacts and around 12% said that it was not a high priority in their organisation at the present time. In total 51% (13%+23%+15%) of respondents stated that their organisations either have measures in place are considering the impacts or have prioritised the risk, while 23% (12%+10%+1%) had either not yet taken any step or had not considered the topic a high priority in their organisation or they lacked technical expertise to take any measures.

Table 35: Organisation approaches for addressing identified climate change impacts

Categories	Frequency	Percentage %
Measures in place	63	13.3
Considering how to deal with impacts	109	23.0
Lack technical expertise	5	1.1
Not currently high priority	59	12.5
Prioritised risk and addressing most important ones	69	14.6
Not yet started considering impacts	47	9.9
Sub-total	*352*	*74.4*
Missing responses	121	25.6
Total	473	100.0

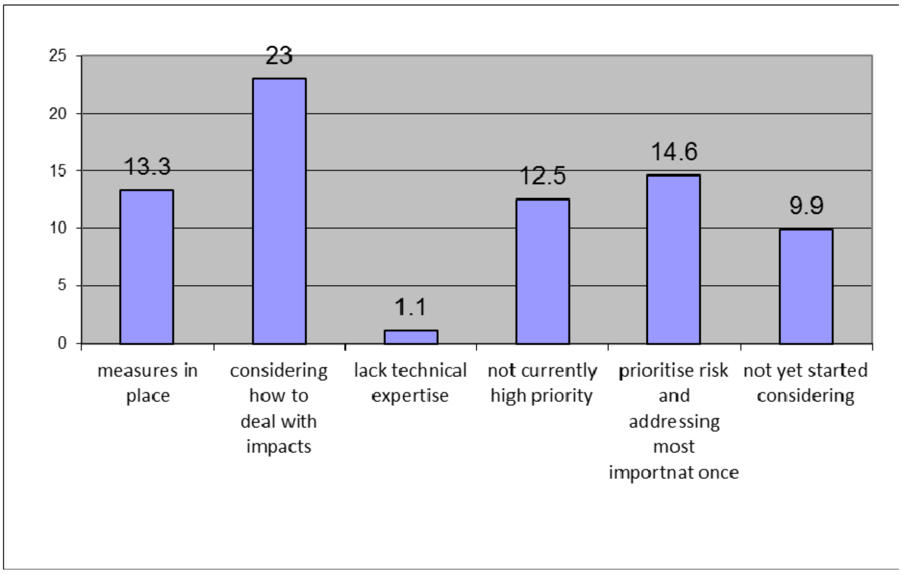


Figure 24: Category responses for addressing climate change impacts

The cross-tabulation shown in Table 36 between respondents' identification of significant and major impacts and measures put in place to address these impacts showed that, of the total of 352 respondents who responded to both the questions, 295 had identified significant/major impacts and from these 54 (18.3%) had measures in place, 94 (31.9%) were considering the impacts, 4 (1.4%) lacked technical expertise, 46 (15.6%) did not consider it a high priority, 62 (21%) had prioritised the risk and were addressing the most important ones, and 35 (11.9%) had not yet started to consider impacts. The results shows that very few FM 's and organisations are taking action for climate change impacts while others are starting to consider how to deal with impacts as they are being increasingly affected by climate related extreme events.

Table 36: Cross-tabulation for anticipated impacts of climate change vs. organisation approach to addressing the impacts

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	No.	Percent	No.	Percent	No.	Percent
Anticipated impacts coded * Organisational approach to impacts	352	74.4%	121	25.6%	473	100.0%

Cross-tabulation

			organisational approach to impacts						
			Measures in place	Considering how to deal with impacts	Lack technical expertise	Not currently high priority	Prioritise risk and addressing most important once	Not yet started considering	Total
Anticipated impacts coded	none to moderate	Count	9	15	1	13	7	12	57
		% within anticipated impacts coded	15.8	26.3	1.8	22.8	12.3	21.1	100
		% within organisational approach to impacts	14.3	13.8	20.0	22.0	10.1	25.5	16.2
		% of Total	2.6	4.3	0.3	3.7	2.0	3.4	16.2
	Significant/ Major	Count	54	94	4	46	62	35	295
		% within anticipated impacts coded	18.3	31.9	1.4	15.6	21.0	11.9	100
		% within organisational approach to impacts	85.7	86.2	80.0	78.0	89.9	74.5	83.8
		% of Total	15.3	26.7	1.1	13.1	17.6	9.9	83.8
Total		Count	63	109	5	59	69	47	352
		% within anticipated impacts coded	17.9	31.0	1.4	16.8	19.6	13.4	100
		% within organisational approach to impacts	100.0	100	100	100.	100	100	100

The private-sector respondents who were able to identify major impacts as a result of changing climate were either starting to consider the impacts or were prioritising the risk. Table 37 presents the response of 114 participants out of 116 who indicated significant or major climate change impacts. There are equal numbers of responses for putting measure in place and not considering the risk as being a high priority in their organisation, suggesting that much of the organisational attitude towards climate change would play a part in taking adaptation actions. Also, higher numbers of responses reporting consideration of such impacts points towards organisation and FM uncertainty about aspects related to climate change action (uncertainty about quantifying future impacts, climate changes itself, response of management and national and local government action).

Table 37: Responses from different sizes of organisation on approach to addressing reported climate change impacts

	Organisational approach to impacts						
	Measures in place	Considering how to deal with impacts	Lack technical expertise	Not currently high priority	Prioritise risk and addressing most important once	Not yet started considering	Total
SME	0	2	0	1	2	3	8
UK Corporate	(6.1%) 3	(49%) 24	0	7	8	6	48
Multinational	(24.1%)14	(27.5%) 16	2	9	15	2	58
Total	17	42	2	17	25	11	114

Identification of impacts can be counted as a first step towards addressing the impacts. The result obtained in Table 37 portrays an overall picture that facilities managers are able to screen the generalised impact depending upon the limited access to detailed information on climate change projections. This is in confirmation to the case study data which cites the uncertainty aspects, the resource requirements of greater risk assessment, data availability and the overall management approach towards climate change as some of the likely reasons for restricted adaptation approaches in the private sector.

In summary, this section supports the evidence from the literature review by observing that experience of climate-related extreme events works as an initiation stage to an adaptation approach through the strengthening of existing disaster-recovery/business-continuity planning for such events and impacts. Although such events generally initiate the likely adaptation process, in the absence of such events facilities managers are able to screen generalised impacts of future climate change projections on their properties. Given the absence of focused understanding about climate change projections, related uncertainty and revenue, time and property data scarcity, the adaptation process in the private sector remains a contained activity.

7.1.4 Questionnaire section 4 – Mitigation measures for climate change

The fourth section of the questionnaire ascertains the mitigation paths taken by surveyed facilities managers and their organisations. The questions enquire about: (a) mitigation measures that facilities managers are taking at present; (b) The drivers for taking those measures; (c) the managers' involvement with institutions that help with mitigation and adaptation; and (d) whether these measures result in any financial gains.

It was hypothesised that, as a result of the UK Government's initiatives and regulations for mitigation, many respondents would indicate mitigation measures as being an integral part of their facilities management strategy. Those sent the questionnaire were asked about routine mitigation measures being part of FM strategy, and a total of 386 out of 473 (81.6%) responded. From these, 210 (54.4%) indicated that mitigation measures for climate change were considered as a routine part of their FM strategy, while 148 (38.3%) suggested that such measures were not performed as a routine measure. A further 28 (7.3%) were unsure of any such activity.

Within the private sector, a majority of respondents indicated that their organisation was taking regular mitigation measures but there still existed a substantial number of SMEs and larger UK corporates who did not take such routine measures. The multinationals were seen to be more inclined towards integrating mitigation measures into their overall FM strategies, mainly because of greater resource availability and level of energy use in such organisations. This general situation is, however, changing as regulations such as CRCs (carbon reduction certificates) have come into action covering the larger UK corporate sector under mitigation legislation. Findings from the questionnaires, with analysis of later questions, will assert that the private-sector action for mitigation follows the Government legislation or responds to market stakeholder calls.

Some mitigation measures were partially covered by facilities managers, i.e. not rolled out across the entire built-asset portfolio, while measures incorporated across all built assets were considered to be fully covered. Amongst the mitigation measures reported, the three most likely to be covered within FM strategy were found to be the following: (i) building stock assessed for energy saving, where 42 % indicated they partially cover the measure and 33% that they fully covered it; (ii) low building consumables procured with 47% partially covering the measure and 33% having covered it fully; and (iii) green energy supplied and tariff is covered partially by 33% and fully covered by 24%.

The three measures tending to be less favourable were found to be training up staff (53%), investing in energy-efficient air conditioning (50%), and checking supply-chain energy efficiency credentials (42%). Furthermore, the following measures were found not to be covered/considered at all (and only partially covered by 30% of respondents): generating the organisation's own renewable energy (51%), carbon offsetting (42%) and retrofitting micro-generation technology (38%).

From the results in Table 38 and Figure 25, it becomes apparent that facilities managers tend to take the following measures, which are either fully or partially covered:

- Building stock assessment for energy saving
- Energy-efficient consumables (e.g. Low energy lightning)
- Green energy supplier/tariff
- Staff training
- Energy credentials of supply chain
- Procurement of efficient new air conditioning (AC) or replacement of an old system with a new, more efficient-efficient one.

Table 38: Frequency count of adopted mitigation measures

Responses categories	**Mitigation Measures**									
	Building stock assessed for energy saving	Ret retrofitting micro generation	Supply chain energy eff.	Training staff (%)	Procuring low building consumables	Invest in energy efficient AC	Green energy supplier and	Own renewable energy (%)	Carbon offsetting (%)	SMART energy metering (%)
Don't know	1.8	6.8	3.2	0.2	0.4	1.3	4.8	3.1	6.8	7.2
Not covered	6.5	38.1	22.6	11.8	3.2	10.4	21.5	51.0	41.8	24.8
Partially covered	41.8	30.2	41.8	52.6	47.0	49.6	32.9	24.2	28.5	35.7
Fully covered	32.7	6.8	15.4	18.9	33.2	22.4	23.9	4.3	6.3	15.6
Missing system	17.2	18.1	16.9	16.5	16.2	16.3	16.9	17.4	16.5	16.7
Total	82.8	81.9	83.1	83.5	83.8	83.7	83.1	82.6	83.5	83.3

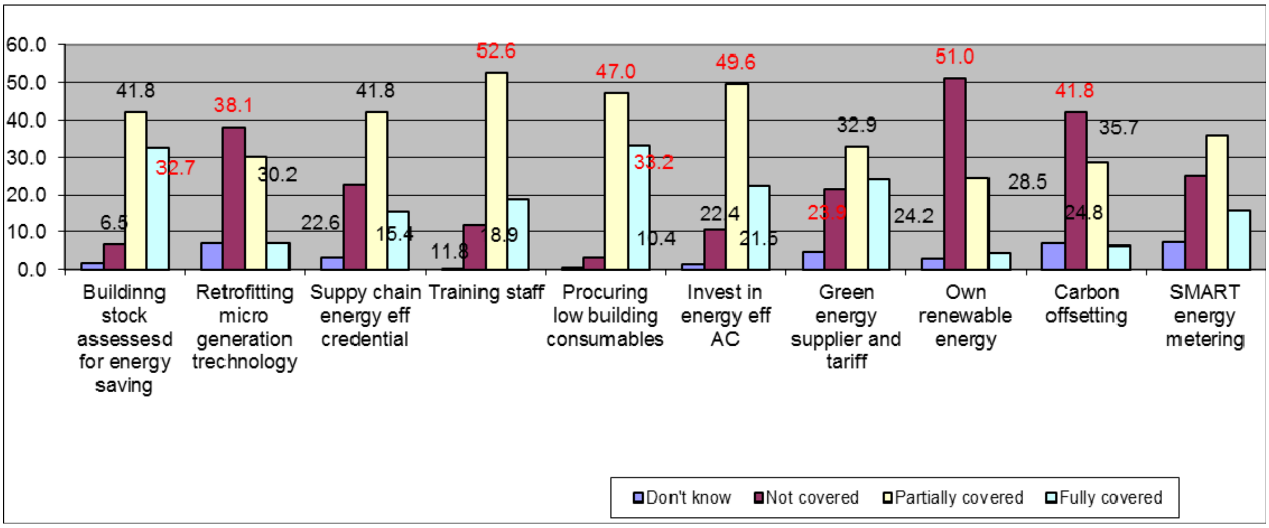


Figure 25: Category responses for adopted mitigation measures

At the time of the survey, facilities management in service sector organisations had still not recognised CO_2 emission offsetting as a priority agenda, as office buildings were not considered to produce vast amounts of CO_2 for trading and there was no internal carbon market set for solely UK-based organisations. This is now altered with the introduction of CRCs. Micro-technology installation or self-generating green energy measures are rarely considered cost-effective.

On the other hand the measures fully or partially covered by FM are those which are possible to cover and implement at operational level with considerable ease. Since organisations' primary CO_2 emissions are from their energy use in offices and through their travel or supply chain, the most likely measures to be taken by FM up till now under a sustainability agenda are measures such as assessing building stock for energy saving, procuring low building consumables and training staff, each of which is more popular nowadays, followed by measures such as investing in energy-efficient AC systems and checking the credentials for supply chain energy efficiency.

Within the private sector, the mitigation measures covered by SMEs, larger corporates and multinationals were found to be in equal proportion, except for investment in energy-efficient AC systems – which was found to be at a higher implementation rate with multinationals probably because of greater resource availability and recently experienced hot summers decreasing their staff's working capacity.

It was assumed that a combination of many drivers would be responsible for facilities managers and their organisations taking mitigation action. The questionnaire revealed CSR and legislation (63.1%) gave the prime impetus for driving organisations' attitudes towards climate change.

Voluntary measures such as FTSE4Good and DOW Jones reporting are considered as secondary drivers by the private sector, especially as these initiatives for private companies to report on their sustainability and emissions are essential tools for maintaining the competitive and marketplace advantage.

The private sector indicated that a climate change levy and enhanced capital allowances are important drivers for their attitude towards CO_2 as they face more energy bills. As time goes on, they are therefore more likely to associate with the Carbon Trust, whose attested product use gives capital allowances and concessions from levies. EPC/Part L is also responsible for driving public-sector organisations. CSR is a major driver for the private sector as it is a question of company image in the marketplace and to consumers/shareholders. This confirms the findings from the participatory study that the legislation driven by the UK Government initiative to achieve CO_2 reduction as its international and EU binding obligations is the major influence for actions for climate change for organisations and their FM staff.

From the foregoing it can be deduced that the drivers for mitigation measures result from the UK Government initiatives and regulation, which organisations perceive to be ever increasing. In order to gain a competitive or first-mover advantage and respond to increased stakeholder and consumer pressure, pre-planned targeted actions are being developed by organisation and FM.

Even so, adaptation is presently reactive in nature and only driven by recurring financial and functional losses experienced through extreme-event occurrence. The insight is missing that pre-planned adaptation allows the option to make properties resilient to future climate change (saving it from obsolescence) and so should be included in regular maintenance planning to bring future savings. Facilities managers' involvement with the institutes and tools for adaptation and mitigation was found to be restricted in cases of adaptation, as shown in Table 39.

As much as 70.6% FM managers were not aware of UKCIP (previously the UK climate change impact programme), an institution established and responsible for climate change adaptation information and tools dissemination; and the London Climate Change Partnership – which looks at larger adaptation and mitigation options for London – has found recognition with only 29.4% (24.3%+5.1%) of respondents, 55.4% not being aware of the partnership. Commercial organisations such as the Carbon Trust that are involved with mitigation measures have nevertheless found recognition and involvement from facilities managers, with 40.6% being aware and 49% involved with it. Two other organisations that FM staff are much aware of and involved with are the Energy Saving Trust and BREEAM.

Table 39: Respondents' awareness and involvement with external climate-change institutions

	UK Climate Impact Programme		**UKCIP framework**		**Energy Saving Trust**		**Carbon Trust**		**London Climate Change Partnership**		**BREEAM**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Aware	69	14.6	62	13.1	230	48.6	192	40.6	115	24.3	132	27.9
Involved	6	1.3	9	1.9	79	16.7	232	49.0	24	5.1	76	16.1
Not aware/ Not involved	334	70.6	336	71.0	114	24.1	33	7.0	262	55.4	211	44.6
Total	409	86.5	407	86.0	423	89.4	457	96.6	401	84.8	419	88.6
Missing	64	13.5	66	14.0	50	10.6	16	3.4	72	15.2	54	11.4
Total	473	100	473	100	473	100	473	100	473	100	473	100

Significant differences are found in the public and private sectors on awareness and involvement with various climate-change-related initiatives. Public-sector organisations are more aware and involved with BREEAM, the Energy Saving Trust and adaptation initiatives such as UKCIP, while private sector companies are more involved with initiatives such as the Carbon Trust and the London Climate Change Partnership (particularly amongst a majority of multinationals and UK-based larger corporates).

The awareness and involvement with initiatives and organisations indicated by FM corresponds to the drivers previously established for organisation action for climate change – for instance, the participation with BREEAM and the Energy Saving Trust increases the organisational credentials for sustainability and environmental buildings and services contributing to the CSR agenda, while participation with the Carbon Trust and measures implemented through participation with it helps with reducing legislatively implied carbon cuts.

Many of the carbon-cut legal regulations and technologies are regarded and propagated as achieving financial efficiency. When asked about financial gain from mitigation measures, 44% of respondents were positive about mitigation measures resulting in financial benefit, while another 32% were not sure about any financial gain and 24% were certain that the mitigation measure has not resulted in any financial gain. This tells us that, in spite of taking mitigation measures, very few facilities managers are confident of the measures delivering any financial gains, the majority of the total (32%+24%=56%) not really being convinced of any financial gain.

This finding stands in a little contradiction with the prevailing general assumption that mitigation measures from energy efficiency and savings result in financial gain. There also exists a probability that the financial gain achieved through the efficiency measures is balanced by investment in maintenance that is required for legislative compliance.

More private-sector than public-sector organisations stated that they were not realising any financial benefit, and more public-sector participants could not say whether they realised any financial benefit. Within the private sector, the number of larger corporate-sector and multinational companies reporting on financial benefits exceeded smaller operating organisations.

In summary, this fourth section of the questionnaire detailed the mitigation measures and their likely drivers in both the public and private sectors. Given the large amount of Government support for mitigation, it was assumed that mitigation measures would be a regular feature for facilities management strategies. In contrast, it was observed that only half of the organisations surveyed included one or more mitigation measures in their routine FM strategy, and many of these were big organisations or multinationals. The reasons cited for this could be greater resource availability and ensuring a better marketplace standing, as disclosed in responses to later questions. It should be noted that at the time of the survey there was no major legislation on curbing emission levels from service sector organisations, which could be regarded as an additional factor for not taking routine mitigation measures.

The mitigation measures taken included easy-to-implement operational actions such as building assessment for energy saving, procuring energy-saving consumables, checking suppliers' energy-saving credentials, and staff training. Among the drivers responsible for these measures, CSR topped the list followed by legislation and voluntary CO_2 disclosure for ensuring early-mover advantage. Carbon Trust and BREEAM were the most favoured institutions that public- and private-sector organisations got involved with for accreditation. The institution supporting adaptation actions, such as UKCIP or LCCP, did not find much popularity within the FM community – although the multinationals and larger corporates tended to have more dealings with them.

There is a wide claim made in the literature that mitigation measures result in financial benefit. This was found to be true only for 44% of respondents, many of which were multinationals. The reasons cited for these companies seeing financial gain were once again the scale of implementation of such measures and the resource availability of the multinationals for such measures.

7.1.5 Questionnaire Section 5 – Opinions about climate change

As evident in much of the literature review and further supported by the observations from the case study, it was deduced that the belief in climate change occurrence supported by an awareness of the environment is likely to affect an individual's or a group's actions for addressing aspects of climate change mitigation and adaptation. In order to provide some quantitative basis for this hypothesis, this section used a new environmental paradigm (NEP) scale (Dunlap et al 2000) measuring the environmental awareness of respondents along with questions regarding respondents' belief in cause and Government action for climate change. The NEP scale was invented by Dunlap and Van Liere in 1978, and then improved later as described in Dunlap et al (2000).

It was intended to establish through NEP a relationship between respondents' beliefs in and attitudes to the various causes of climate change. For instance, it was presumed that a higher score on the NEP scale would also show a higher score of agreement with human-induced climate change responses, and this implies that an organisation is more likely to take mitigation and adaptation action – i.e., the more environmentally inclined respondents are, the more they will endorse the belief that 'human activities have contributed to climate change' and thus take mitigation action.

A selection of the following eight balanced items was made for the purpose of this research's questionnaire using the NEP scale:

1) The balance of nature is very delicate and easily upset.
2) When humans interfere with nature, it often has disastrous consequences.
3) Mankind was created to rule over the rest of nature.
4) The Earth is like a spaceship, with only limited room and resources.
5) The so-called 'ecological crisis' facing humankind has been greatly exaggerated.
6) Humans have the right to modify the natural environment to suit their needs.

7) Human ingenuity will ensure that we do not make the Earth unliveable in.

8) If things continue on their present course, we will soon experience a major ecological catastrophe.

The participant's agreement to each statement was sought on the scale of 1 to 5, where 1 represented strong disagreement and 5 represented complete agreement with the statement. A total NEP score was then calculated. According to the statement of each item and the corresponding highest score, the balanced (mean) positive score would be 28: a score of 5 for each of NEP 1, 2, 4, 7 and 8 (a total of 5×5=25) and a maximum-disagreement score of 1 for NEP 3, 5 and 6 (total 1×3 =3), giving 25+3=28. The statistical results can be found in Tables 40–42. The accompanying graph in Figure 26 shows that a majority of respondents' scores lie between 23 and 36, indicating an environmentally aware FM community.

These results suggest that facilities managers agree that there are limited resources available and that an appropriate and efficient use of these resources is important – but at the same time those managers are not sure whether their collective efforts will result in some environmentally positive feedback.

Table 40: Statistical analysis of responses for NEP scale

	NEP1	NEP2	NEP3	NEP4	NEP5	NEP6	NEP7	NEP8
Mean	3.7	3.7	4.0	3.7	3.2	3.4	2.8	3.3
Median	4.0	4.0	4.0	4.0	3.0	4.0	3.0	3.0
Mode	4.0	4.0	5.0	4.0	3.0	4.0	3.0	4.0
Std. deviation	1.1	1.0	1.3	1.2	1.3	1.2	1.2	1.2
Variance	1.2	1.0	1.7	1.4	1.6	1.5	1.5	1.4
Skewness	-0.9	-0.8	-1.4	-1.0	-0.3	-0.6	-0.3	-0.8
Std. error	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Kurtosis	1.0	0.9	1.3	0.9	-0.2	0.0	-0.5	0.4
Std. error of kurtosis	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Range	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Valid	470.0	462.0	465.0	464.0	467.0	462.0	459.0	465.0
Missing	87.0	95.0	92.0	93.0	90.0	95.0	98.0	92.0

Table 41: Frequency count of NEP scale responses

	Don't know	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Total	Missing
NEP1	1.4	1.6	7.5	21.5	32.3	19.9	84.4	15.6
NEP2	0.9	0.9	7.2	21.4	33.6	19.0	82.9	17.1
NEP3	2.7	3.4	3.2	15.4	17.2	41.5	83.5	16.5
NEP4	1.6	2.7	6.8	17.2	30.5	24.4	83.3	16.7
NEP5	3.1	3.6	16.7	28.7	16.5	15.3	83.8	16.2
NEP6	2.2	2.5	13.1	22.3	24.6	18.3	82.9	17.1
NEP7	3.2	10.1	18.3	25.3	21.0	4.5	82.4	17.6
NEP8	3.1	3.9	11.1	24.4	30.3	10.6	83.5	16.5

Table 42: Statistical analysis of respondents' total NEP score

Valid	453
Missing	104
Mean	27.80574
Median	28
Mode	28
Std. deviation	5.14629
Variance	26.4843
Skewness	-1.6933
Std. error of skewness	0.114708
Kurtosis	6.979258
Std. error of kurtosis	0.22892
Range	40
Minimum	0
Maximum	40

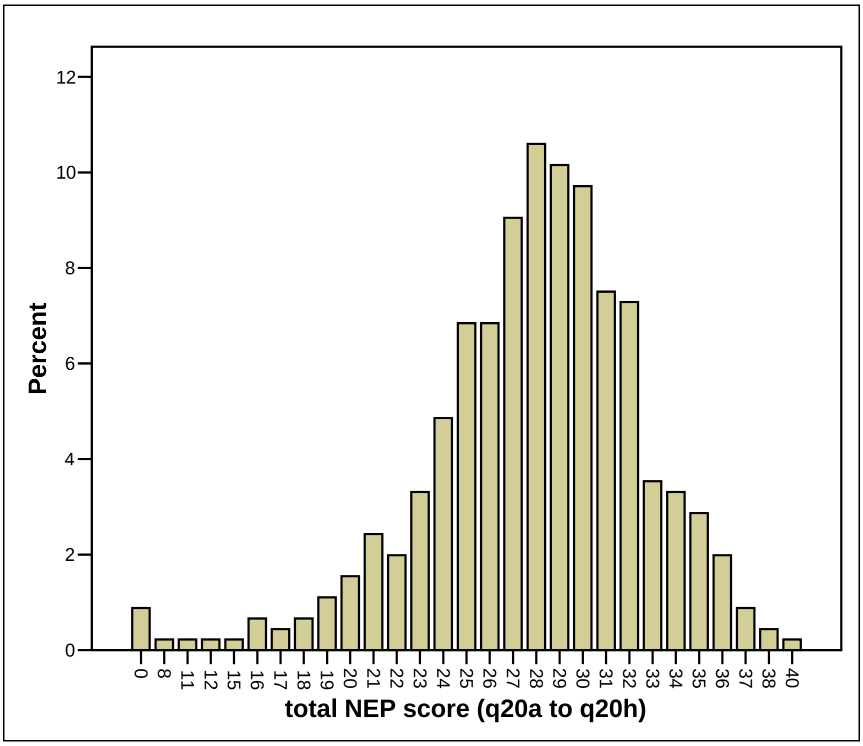


Figure 26: Histogram of NEP scale responses

The later questions enquired about climate change cause and action through agreement with the following statements:

Q20(i) Climate change is a naturally occurring phenomenon and human activity has not significantly contributed to it.

Q20(j) Private organisations will only reduce their carbon emissions in response to Government legislation.

Q20(k) Industries are not convinced that Government has clear policies to tackle climate change.

Q20(l) Climate change is primarily a political tool for raising additional taxation.

The statistical information and graph presented in Tables 43 and 44 and Figure 27 make clear that the statement relating to FM opinion about a cause of climate change as embodied in Q20(i) ('Climate change is a naturally occurring phenomenon and human activity has not significantly contributed to it') has mean=3.3 and SD=1.3, indicating that in overall terms facilities managers are not clear whether climate change is caused by human activities or is a naturally occurring phenomenon.

Table 43: Respondents' agreement with anthropogenic causes for climate change (statistical analysis)

Valid	459.0
Missing	98.0
Mean	3.3
Median	3.0
Mode	4.0
Std. deviation	1.3
Variance	1.7
Skewness	-0.7
Std. error of skewness	0.1
Kurtosis	0.0
Std. error of kurtosis	0.2
Range	5.0
Minimum	0.0
Maximum	5.0

Table 44: Respondents' agreement with anthropogenic causes for climate change(frequency count)

	Don't know	**Strongly disagree**	**Disagree**	**Neither agree/nor disagree**	**Agree**	**Strongly agree**	**Total**
Frequency	22	18	73	117	140	89	459
Percentage	3.9%	3.2%	13.1%	21.0%	25.1%	16.0%	82.4%

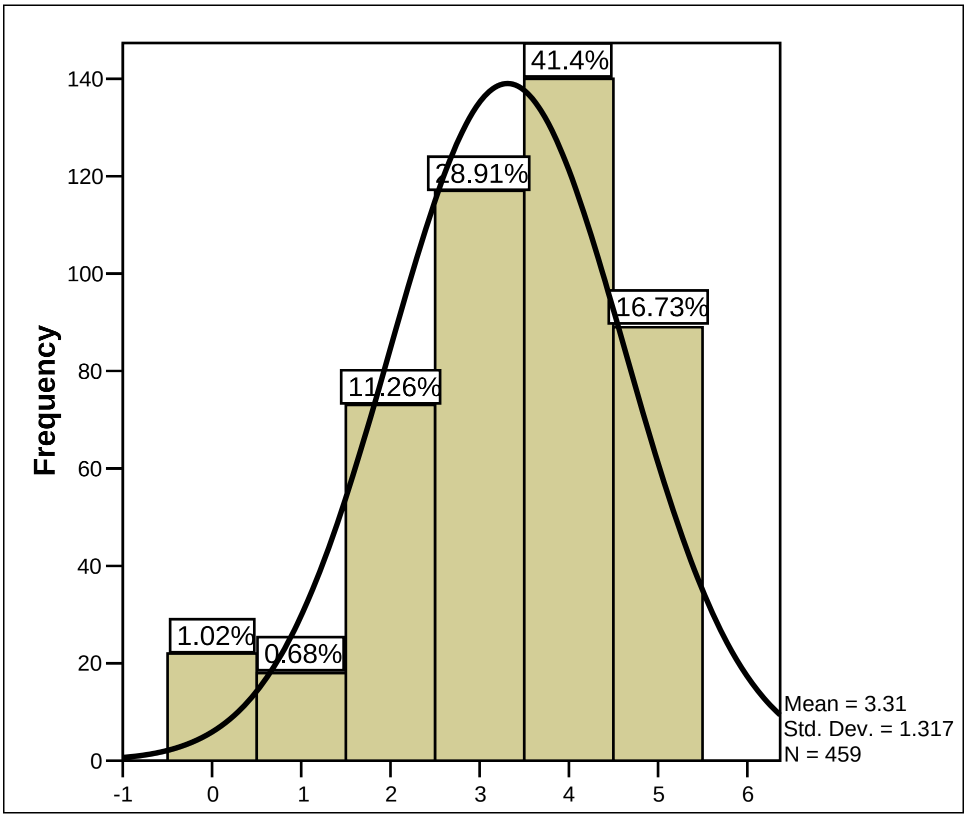


Figure 27: Responses for belief in anthropogenic climate change – histogram

The belief in the cause of climate change (i.e. climate change is human-induced) was found to be at differing levels among facilities managers as per the size of the organisation they belonged to. A facilities manager in an SME and middle-sized organisation tended to indicate lesser agreement that the cause of climate change is anthropogenic emission, while managers in multinationals and larger organisations tended to show greater agreement that human activities are largely responsible for climate change. This is related to higher levels of mitigation measures by larger organisations in addition to greater resources available to such organisations.

The statement embodied in Q20(j) ('Private organisations will only reduce their carbon emissions in response to Government legislation') has mean=3.7 and SD=1.2, and a majority of respondents either agreeing or strongly agreeing, informing that facilities managers see legislation as a prime driver for mitigation measures taken by organisations. See Tables 45 and 46 and Figure 28.

Table 45: Respondents' agreement with Government legislation being a driver for private-sector CO_2 emission reduction (statistical analysis)

Valid	468
Missing	89
Mean	3.675214
Median	4
Mode	4
Std. deviation	1.180346
Variance	1.393217
Skewness	-0.96512
Std. error of skewness	0.112867
Kurtosis	0.462812
Std. error of kurtosis	0.22526
Range	5
Minimum	0
Maximum	5

Table 46: Respondents' agreement with Government legislation being a driver for private-sector CO_2 emission reduction (frequency count)

	Don't know	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Total
Frequency	7	20	56	68	201	116	468
Percentage	1.256%	3.590%	10.053%	12.208%	36.086%	20.825%	84.021%

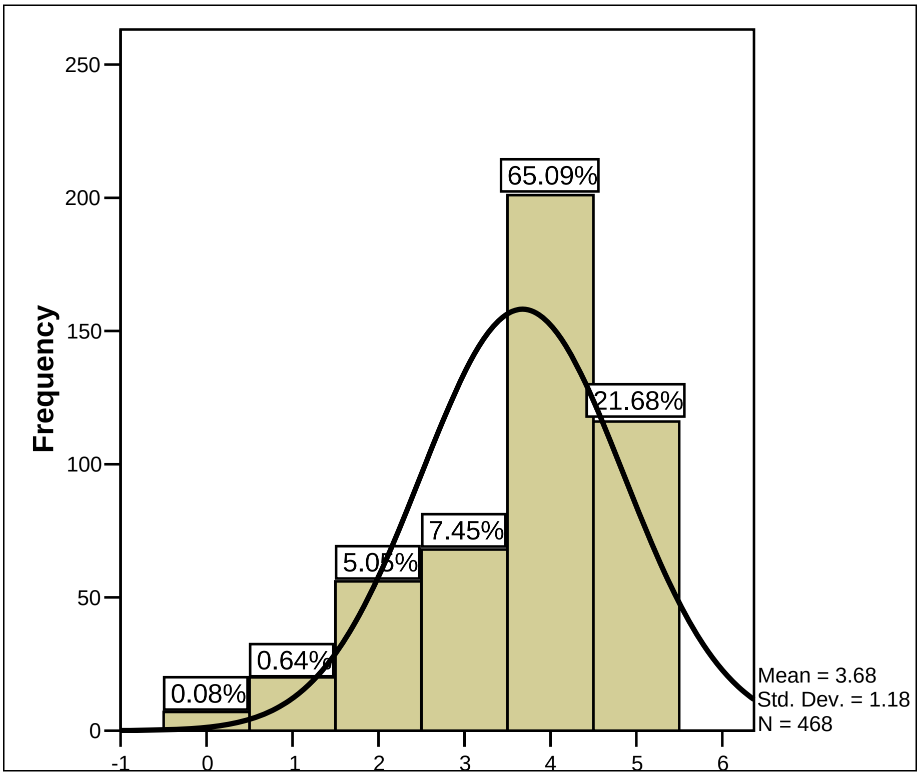


Figure 28: Response for belief in legislation-led climate change response in private sector – histogram

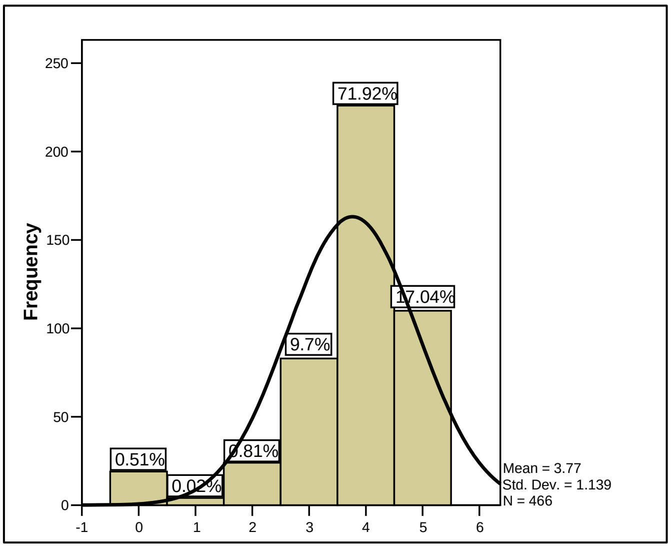
The last two statements are combined to demonstrate FM perception about Government actions and initiatives about climate change (see Tables 47 and 48 and Figures 29 and 30). The combined score for strong agreement to both items would be (5+5=10). So if a respondent scored 10 as a combined score for both items, it could be said that the respondent is in strong agreement that the Government needs to have clear guidelines for tackling climate change and that it should not use it as just a tool to gather more taxes from private organisations.

Table 47: Responses on Q20(k) (unclear Government policy) and Q20(l) (taxation tool) (statistical analysis)

	Mean	**Median**	**Mode**	**Std. deviation**	**Range**	**Min**	**Max**	**Valid**
Unclear government policy	3.8	4	4	1.1	5	0	5	466
Taxation tool	2.6	3	3	1.3	5	0	5	464

Table 48: Combined scores of Q20(k) (unclear Government policy) and Q20(l) (taxation tool)

Valid	463.0
Missing	94.0
Mean	6.4
Median	6.0
Mode	6.0
Std. deviation	1.9
Variance	3.6
Skewness	-0.8
Std. error of skewness	0.1
Kurtosis	1.2
Std. error of kurtosis	0.2
Range	10.0
Minimum	0.0
Maximum	10.0



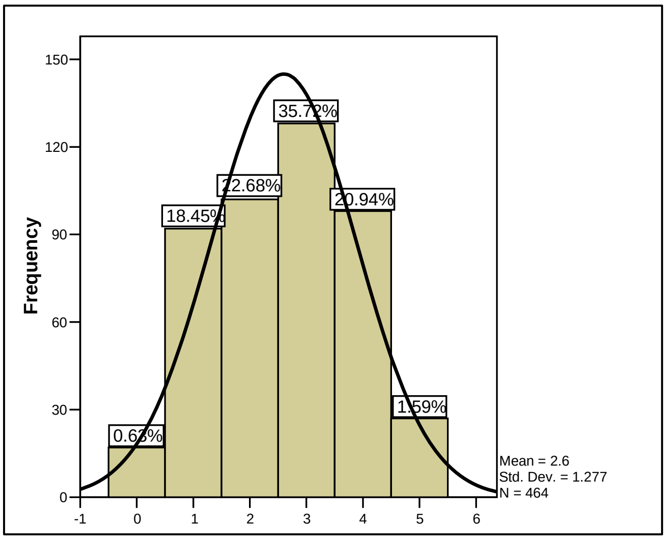


Figure 29: Responses for Q20(k) (unclear Government policy) – histogram
Figure 30: Responses for Q20(l) (taxation tool) – histogram

Tables 47 and 48 for the above analysis shows mean=6.4, SD=1.9, and 73% of facilities managers scoring 6 or more, suggesting a majority of those managers believe that the (UK) Government does not have clear guidelines on climate change in place, and that climate change is being used as a tax-collecting tool.

In order to gather participants' views on climate change adaptation and mitigation, the subsequent question 21 in the questionnaire asked about any additional action the respondents think they could undertake in relation to mitigation or adaptation. The findings of this question were not in line with expectations. It was expected that after refereeing the definition of adaptation and mitigation within the questionnaire and after wider attention had been given to the subject at the time of the research, the participants would be able clearly to distinguish between adaptation and mitigation actions. Instead, many of the answers were found to be displaced within the adaptation and mitigation categories. Indeed, from 153 (32%) replies, which asked about suggested actions about adaptation, only 52 (33%) out of the total actually related to adaptation measures; and from 129 (27%) replies on suggested actions about mitigation, there were 23 (18%) comments made for adaptation measures.

This tells us that very few FM can distinguish between adaptation and mitigation concepts. FM prioritises actions in order of compliance with legislation, energy efficiency measures and efficient transportation methods. From the comments made via the questionnaire, it could be observed that facilities managers consider 'adaptation' as adaptation to energy efficiency and legislation compliance, and 'mitigation' as mitigation from the effects of climate change on their properties. Thus, FM recognition of the concepts of adaptation and mitigation are somewhat turned on their head as compared with the definitions prevailing within the scientific community.

In summary, the results from this part 5 of the questionnaire indicated that the general perception and ambiguity about the nature and cause of climate change was persistent in the early years of Kyoto protocol among many businesses. It has also prevailed in the overall FM community, indicating an ambiguity as to whether there is agreement on the human-induced climate change. Facilities managers are generally of a strong opinion that only legislation will make private-sector organisations cut their emissions and that there is a lack of clarity on (UK) Government policy for curbing the emissions. Also, there is not complete agreement that the present legislation is actually achieving the overall CO_2 reduction targets and there is some general view that the legislation is used merely as tool to generate additional revenue.

The correlation tests presented in later section support the hypothesisthat respondents with higher environmental awareness hold a stronger belief in human-induced climate change. This in turn was found to be positively related to the view that Government legislation must make private-sector organisations reduce their emissions.

7.2 Correlations

For the purpose of validating the hypothesis set out in Chapter 6, correlation tests were carried out among the selected variables. During the process of justifying the chosen hypothesis, a relationship map for adaptation and mitigation approaches was formulated. This map was later used for supporting the results and adaptation process observed during the participatory study.

As mentioned in Table 14of Chapter 6, the four primary questions derived from the three participatory-study observation conclusions were responsible for generating six workable hypotheses and related variables. The following pages state the conclusion, derived questions and related hypotheses in each case, and the correlation tests for validation and rejection of each hypothesis.

7.2.1 Primary question 1

Participatory study observation conclusion

Ob1) The organisation's and the facilities managers' perceptions of risk, associated with a belief in the occurrence of climate change, affects the approach taken.

Derived question

Q1) What are the facilities managers' perception and opinion about climate change (mitigation and adaptation)?

Hypotheses

H1) Climate change is seen as an opportunity for new services, products and financial saving.

H2) FM environmental inclination is presumed to be high and it may affect their belief of climate change occurrence and in turn their action, especially for mitigation.

Hypothesis H1 could be validated from the basic frequency count of questionnaire Q7, where majority of the respondents reported that climate change will affect the way their FM function provides services (mean=3.93, SD=0.8) and also the way it perceives climate change as an opportunity to develop new products (mean=3.98, SD=1.04). Also, the view that climate change represented a risk to organisational functioning received a balanced response (mean=3.39, SD=1.1), establishing that the perception of climate change as a future risk is not very prevalent within the FM community. This (as will be seen in progressive correlations) will be a component partly responsible for future climate change adaptation.

Hypothesis H2 was tested by a correlation test carried out amongst the following variables:

- NEP score
- Belief in climate change occurrence
- Perception of climate change as a risk
- Organisational approach to addressing climate change impacts.

Tested in two parts, first the relationship was established between the respondents' environmental awareness, their belief in human-induced climate change and their resulting perception about the future climate changes. The later part established the relationships between the perception of climate change and the approach towards climate change mitigation and adaptation.

In support of the first part of hypothesis H2, the following correlations were established as detailed in Appendix 11.

- Environmental awareness and belief in human-induced climate change (R1)
- Environmental awareness and perceiving climate change as a risk (R2)
- Belief in human-induced climate change and perception of risk (R3)
- Environmental awareness and climate change being used as a taxation tool (R4)
- Belief in human-induced climate change and climate change being used as a taxation tool (R5).

For R1, the Spearman's correlation between environmental awareness (represented by total NEP score) and the variable in questionnaire Q20 (i) (belief in climate change occurrence) was found to be positive and significant with r = 0.440 (medium strength), N= 168 and P<0.01. (Note that Cohen 1998 (as cited in Pallant 2005) uses the following definitions for possible values of r: mod r from 0.10 to 0.29 is 'weak', mod r from 0.30 to 0.49 is 'medium', and mod r from 0.50 to 1.00 is 'strong'. This means that 19.3% of variance (Ref R1 in appendix 11) in belief in human-induced climate change can be explained by an individual's environmental awareness in the survey population.

For R2, the perception of climate change as a risk was also found to be positively correlated to environmental awareness, with r=0.230 (weak), n=79 at the P<0.05 level. A low 5.9 to 6% variance in perception of climate change as a risk could be explained by environmental inclination.

With regard to R3, an overall belief in climate change was found to be positively related to perceiving climate change as a risk, with r=0.309 (medium), n=166, P<0.001, which explains a 9.5% variance in climate change perception being explained by belief in climate change occurrence.

For R4, the correlation between environmental awareness and viewing climate change as merely a taxation tool was found to be negative, with r=–0.247 (weak), n=166 and P<0.001. This explains 6.7–7.0% variance shared between the variables.

In a similar way re R5, the correlation between belief in human-induced climate change and viewing climate change as a taxation tool was also found to be negative, with r=–0.459 (medium), n=164, P<0.01, explaining a 21 % variance. The correlation, although not quite in the high/strong part of the scale, helps explain the direction of the relationships.

Factors such as organisational size, personal knowledge, resources and experience of an extreme event will also play a part in these correlations. A factor analysis would have been helpful in establishing these exact relationships, but owing to limitations on the data received this was not possible. In spite of this, some of the correlations are established in later sections below of this thesis.

The established correlations support the hypothesis that initial positive environmental awareness helps towards formulating a view that human-induced climate change is occurring and that in some ways it represents a risk. It is also to be noted that individuals with a belief in human-induced climate change showed a support for mitigation initiatives by the (UK) Government.

The second part of hypothesis H2, namely that an organisation's approach to address climate change reflects beliefs and perception about climate change, is supported by the following correlations R6 and R7, which are also set out in Appendix 11:

- Positive environmental awareness supports mitigation action in an organisation (R6)
- An organisation's approach to adaptation reflects its perception of climate change risk (R7).

In relation to R6, the chi-square test was performed to determine whether participants with higher environmental awareness would be more inclined to take routine mitigation measures within their organisation. The test showed that there is a significant difference ($x^2(3)=8.439$, $P=0.038 <0.05$}, where people with moderate-to-high environmental awareness indicated taking routine mitigation measures compared with those who reported lower awareness.

For R7, the perception of climate change as a risk was found to be related to adaptation actions as 81% of participants with a perception of climate change as a risk indicated that their organisation was taking some measures for adaptation towards predicted climate change impacts, compared with 19% who did not. The test results gave $x^2(1)=12.154$, $P= 0.0001<0.005$.

7.2.2 Primary question 2

Participatory study observation conclusions

Ob2) Reliance on past experience of weather events, and difficulty in translating climate change projections into business operational risk were observed. Areas of concern centred on uncertainty relating to climate change projections and an absence of micro-level probability data.

Derived question

Q2) Does past experience of an extreme weather event change a facilities manager's perception of climate risk (in terms of business function / asset management), and is this the key to implementing adaptation measures?

Hypotheses

H3) The long-term climate change impacts are less likely to be addressed compared with the experience of an extreme event, which results in a perception of climate change as a risk to the business function (due to losses experienced). It is the prime reason for facilities managers to identify and consider future climate change to be included in disaster recovery (risk assessment).

H4) Facilities managers are largely unaware of much of quantitative climate change risk assessment, and adaptation initiatives such as UKCIP.

Hypothesis H3 is established through the correlation test amongst the following, where a positive correlation between (a) experience of an extreme event vs perception of risk (chi square), and (b) and extreme event vs addressing climate change adaptation, will confirm hypothesis H3. Hypothesis H4 is confirmed by presenting the basic frequency count for the questionnaire Q18, which enquires about the awareness and involvement of organisations in institutions promoting adaptation and mitigation.

The correlations stated above were confirmed by Spearman's test for the correlation for non-parametric data, where the two variables are ranked and dichotomous. (The ranked variables were converted to indicate dichotomy.) The chi-square statistical tables are presented in Appendix 12.

Under condition (1) in Appendix 12, the chi-square test shows that there is a significant difference in participants' risk perception where the participants indicated experiencing extreme weather events as compared with those who did not, with x^2 (1) = 4.261, P = 0.039 <0.05.

For condition (2) in Appendix 12, the correlation of an extreme event experience and addressing climate change adaptation has also been found to be significant, whereby 56.2% of participants experiencing an extreme event had shown a positive approach to climate change adaptation, as compared with 43.8% who did not. The chi-square test shows the difference as $x^2(1) = 6.585$, P= 0.010<0.05.

The basic frequency count for questionnaire Q18, which asks about the participant's involvement with institutions offering advice with climate change mitigation and adaptation, was used for validating hypothesis H4. The hypothesis was confirmed, because (see Appendix 12 condition (3) from a total of 86.5% responses received for the question, 70.6% of the participants were not aware or involved, 14.6% were aware and only 1.3% were involved with UKCIP, the institute responsible for adaptation.

This low awareness and involvement is also reflected in the adaptation approach of the respondents, where only 51% of respondents had started addressing adaptation in some form or other, or had prioritised the risk, while 23% of respondents had not taken any measures to address adaptation for organisational or technical reasons.

This trend has recently been observed to be altering with the UK Government's Climate Change Act 2008 and NI188 having passed into law, whereby every public authority is now required to put forward a climate change adaptation/preparation plan. In the private sector, the many small and medium-sized (SME) organisations are now engaging with UKCIP for better preparedness for future climate changes. In spite of this, the overall awareness and preparedness in the private sector for future climate change impacts remains low.

7.2.3 Primary questions 3 and 4

Participatory study observation conclusions

Ob3) Adaptation is seen as operational, while mitigation is strategically driven with long-term planning and adaptation action occurring as a reaction to a weather-related or extreme event.

Derived questions

Q3) What actions have been taken for climate change adaptation and mitigation (and are they strategic or operational)?

Q4) What are the correlations between adaptation, mitigation, and operational and strategic planning?

Hypotheses

H5) Mitigation measures are driven through CSR (legislation compliance) and financial gain (through reduced taxation and energy saving). It is strategic in nature.

H6) As a result of an extreme event impact, FM can identify the overall risk (qualitative risk screening), which becomes a basis for considering climate change into risk assessment. Thus the adaptation process is reactive instead of planned.

Hypothesis H5 deals with aspects related to drivers responsible for mitigation. It was hypothesised that mitigation efforts translated by the UK Government into legislation are responsible for shaping up the CSR (corporate social responsibility) and mitigation targets of an organisation, which directly affects FM mitigation strategy. It is also been conjectured that the extensive external support and advice available to organisations through institutions that focus on helping with mitigation and adaptation, and the financial gain that comes through mitigation measures, are also partly responsible for driving mitigation within organisations at a strategic level.

This hypothesis H5 is validated through a basic frequency analysis and correlation amongst the three following variables:

1) Basic frequency count of drivers responsible for mitigation action, as reported by the respondents (R1)
2) Correlation between the routine mitigation measure and drivers for the measures (financial and CSR) (R2)
3) Involvement with external institutions and the financial gain that comes through routine mitigation measures (R3).

With regard to the first variable above, questionnaire Q17 is relevant as it enquired about the drivers responsible for mitigation action in each respondent's organisation. Since the question was a multiple-choice question, many of the categories were amalgamated for the analysis; and this revealed that CSR and legislation (63.1%) are prime drivers for the action, followed by voluntary and other drivers. This validates the first part of the hypothesis, namely that the mitigation measures are driven through CSR and legislation.

By establishing a correlation between each participant's indication of taking mitigation measures as a routine part of FM strategy and the probable financial and legislative drivers, the second part of hypothesis H5 is validated. This confirms that the mitigation initiatives are shaped by financial savings and organisational CSR, which are responsive to Government legislation. The chi-square correlation shows the difference as $x^2(1) = 6.778$, $p = 0.009 < 0.05$. The table of statistics for R1 in Appendix 13 shows that 93.3% of respondents indicating CSR as a driver also agree that they have gained financial benefit from mitigation measures.

For R2, the chi-square correlation is significant, with $x^2(1)=7.197$, $p=0.007<0.05$, and the cross-tabulation in Appendix 13 for R2 shows that 57% of respondents who considered mitigation measures as a part of their routine FM strategy agreed that mitigation measures give financial benefit. Also, 30% of respondents who said 'no' to considering mitigation measures as a part of their routine FM strategy were not able to admit to any financial gain from mitigation measures.

The third part of hypothesis H5 needed to establish that the support from external institutes is responsible for the financial benefits from the routine mitigation measures and thus drives the strategic FM decision for implementing mitigation measures. The chi-square correlation for R3 in Appendix 13 presents the difference as $x^2(2)=15.373$, $p=0.0001<0.05$. The cross-tabulation shows that involvement with the Carbon Trust resulted in respondents' acknowledgement that mitigation measures resulted in financial benefit.

The validation of hypothesis H6 establishes a correlation observed quantitatively in the participatory study in the implementation of the UKCIP framework. It also constitutes the framework of correlation to be used in further logistic regression analyses for providing evidence for the adaptation process observed in the case study.

The correlations relevant to hypothesis H6 (and reported in Appendix 14) are as follows:

1) Relationship between identifying the impacts and considering impacts of the future climate changes in disaster recovery planning or risk assessment (R1)
2) Perception of risk vs. identification of impact (R2)
3) Participants' reported perception of climate change as a risk vs. considering the impacts of future climate changes (R3)
4) Experience of an extreme event vs. considering future climate change impacts (R4)
5) Experience of an extreme event vs. identification of impact (chi-square) (R5).

The chi-square correlation for R1 in Appendix 14 shows the difference as ($x^2(1)=7.233$, $p=0.007<0.05$), where 72% of respondents with an ability of identifying the impacts as major or significant had indicated that they were considering future climate change impacts for risk assessment (compared with 50.9% who did not).

The perception of risk was found to be significantly and positively correlated to the identification of future impacts due to various climate change effects, as set out for R2 in Appendix 14. Table 49 presents a summary of the statistical results.

Table 49: Correlation between perception of risk and ability to indentify future impacts

Correlation variables	Correlation results
Impact due to more winter rain α Perception of risk	r=0.268, n=81, p=0.016 <0.05
More frequent storms α Perception of risk	r=0.437, n=82, p=0.0001 <0.05
Decreased Snowfall α perception of risk	r=0.347, n=81, p=0.002<0.05
Increased winter temperature α perception of risk	r=0.251, n=81, p=0.024<0.05
frequent and severe flooding α perception of risk	r=0.365, n=81, p=0.001<0.05
more extremely hot summers α Perception of risk	r=0.293, n=81, p<0.008<0.05
more summer droughts α perception of risk	r=0.242, n=81, p<0.030<0.05
changes in seasonality α perception of risk	r=0.270, n=81, p<0.015<0.05

With regard to participants' reported perception of climate change as a risk vs considering the impacts of future climate changes (R3), the chi-square test showed a significant difference with $x^2(1)=5.198$, n=100, $p=0.023<0.05$ (see Appendix 14 – R3). It is possible to establish that perception of climate change as representing risk contributes to considering future climate change impacts as a result of extreme event occurrence, because 69% of participants who did not perceive climate change as risk did not consider future impacts of climate change after experiencing an extreme event. It was also observed that only identifying the impacts showed no relation to the adaptation approach in the absence of an extreme-event experience and maintained the perception of climate change as a risk. This emphasises that risk perception and experiencing climate-related events are essential components for an organisation's adaptation approach.

In relation to experience of an extreme weather event versus considering future climate change impacts, it was observed that 78% experiencing a climate-related event had considered similar future climate change impacts for addressing in their disaster recovery planning, compared with 21.9% who did not. The chi-square test showed a significant result: $x^2(1)=63.175$, $p=0.0001<0.005$ (see Appendix 14 – R4).

The extreme-event experience was found to be related to identification of impacts, because 78.3% of participants who had experience of at least one extreme weather event had indicated significant or major climate-change impacts, compared with 21.7% who did not experience any extreme event. The relevant chi-square test (see Appendix 14 – R5) presents the difference as $x^2(1)=13.032$, $p=0.0001< 0.05$.

7.3 Chapter summary and conclusions

This chapter has presented an analysis of the questionnaire survey carried out primarily to support or reject the primary observations made through the participatory study. The basic frequency count of the questions concluded that the survey was answered by the targeted population, where almost equal numbers of facilities managers from the public and private sectors responded. These responses were almost equally distributed across various organisation sizes (e.g. SME, medium-sized corporations, and multinationals). The majority of respondents were senior facilities managers or executive facilities managers, who are more likely to be involved in strategic FM decision making. Overall, facilities managers perceive their climate change awareness and knowledge to be adequate but at the same time they do not perceive climate change as presenting a risk to their facilities and service delivery.

A general perception prevails that climate change will alter the way that services have been delivered till now and may provide an opportunity to develop the delivery of new products. Although many of the organisations polled have been active in addressing climate change mitigation, many still remain as laggards for implementing any kind of action. In support of the evidence from the literature review, the questionnaire observed that experience of a climate-related extreme event is very likely to initiate an adaptation approach through the strengthening of existing disaster-recovery and/or business-continuity planning for such events and impacts. Although such events are likely to initiate the adaptation process, it was found that, in the absence of such events, facilities managers are able to screen filter out of consideration the generalised impacts of future climate change projections in relation to their properties.

With regard to mitigation, as a result of the UK Government's drive for increasingly stringent targets, mitigation measures have become a regular feature for facilities' management strategies. The larger organisations are able to achieve higher targets, due to their resource availability, as compared with their medium-sized and SME counterparts. Financial benefits from the mitigation measures were also cited by many of the respondents of the questionnaire as being generated.

Although in overall terms the FM community was positively environmentally inclined and aware, there still persisted ambiguity amongst respondents about the cause of climate change and a certainty on the one hand that only Government legislation would reduce the emission and that there were no clear guidelines available on the regulations being imposed, while on the other hand many of the respondents were of an opinion that the carbon taxation and legislation had not really helped in reducing emission levels. This finding remains to be validated through future research.

Correlation analyses were carried out to validate the hypotheses set out from the operational statements for the questionnaire (which are themselves laid out in Table 14 within Chapter 6) The collective validity of the stated hypotheses forms the basis for further analysis through a logistic regression process. The results of that process confirm the responsive adaptation process observed through implementation of the UKCIP decision-making framework in the participatory study organisation. Chapter 8 summarises the logistic regression analyses and compares them with the participatory study observations and wider adaptation concepts.

Chapter 8: Logistic regression

This chapter presents logistic regression as a further step to the correlation analysis described in Chapter 7. Section 8.1 outlines the basis of logistic regression. Section 8.2 explains the different regression analysis tests planned and the rationale for the same. Subsequent section 8.3 reports the results of the regression analysis and section 8.4 summarises the chapter.

8.1 Regression analysis

Regression analysis is the next step after establishing correlation. Correlation indicates that the variables are in some way related to each other (positively or negatively); regression analysis can provide significant predictors of a specific outcome and thus a model to fit the data gathered. Field (2005) describes liner regression in general terms as

$$\text{Outcome} = (\text{model}_1) + \text{error}_1 .$$

At the end of a regression analysis an equation can be produced for a straight line which can best fit the data received, presented as

$$Y = (b_0 + b_1 x_1) + \varepsilon_1 .$$

Here Y is the outcome to be predicted, x_1 is the participant's score, b_1 is the gradient of the line and b_0 is the intercept of the line. Variables b_0 and b_1 are known as the regression coefficients (Field 2005). The term ε_1 represents an error factor.

The two major types of regression analysis are simple and multiple regressions. In simple regression an outcome variable (known as the dependent variable –DV) is predicted by a singular predictor variable (an independent variable –IV) while in multiple regression there are more than one predictors involved to derive an outcome. (More explanation can be found in Field 2005 and Tabachnick and Fidell 1983).

For multiple regressions the data needs to be normally distributed and the variable measures should be continuous in nature. In cases of violation of these two conditions, logistic regression is the statistical choice made. In principle, linear single and multiple regressions directly predict the value of outcome Y, given the various data points and their related coefficient; with logistic regression, a probability of Y is calculated given the value of different data points and their respective coefficients. This is represented in equation form as

$$(bo + b_1 x_1 + b_2x_2 ... + b_ix_i) \text{ where } (x_1\text{= Data points, } b_1\text{=Coefficients})$$
$$P(Y) = 1/ (1+e^{-1})$$

This is further expressed as

$$Ln[Y/(1-Y)] = e\ (b_o + b_1x_1 + b_2x_2 ... + b_ix_i)$$
$$Logit(Y) = b_o + b_1 x_1 + b_2x_2 ... + b_ix_i$$

$$Log(odds) = Logit(Y) = b_o + b_1 x_1 + b_2x_2 ... + b_ix_i$$

Thus the logistic regression is an expression of multiple regression equations in logarithmic terms, which does not violate the assumption of linearity (Field 2005).

8.2 Adopting logistic regression and the related rationale

The regression analysis is carried out for two purposes: first, for establishing the adaptation process observed in the participatory study, which was also found to be in accordance with the adaptation concepts mentioned in the literature; and, secondly, to look for factors affecting mitigation action as reported once again in accordance with the participatory study observations and literature evidence.

Although logistic regression does not produce very strong modelling results, it is primarily used here to establish an overall conceptual process observed for adaptation and mitigation through the participatory study and literature review. The paragraphs below describes the logistic regression carried out for outlining the adaptation process observed in the participatory study and the questionnaire data received, followed by logistic regression for the mitigation action as reported by both in the literature and by the participants and

8.2.1 Regression for establishing an adaptation process

In the present research the regressions analysis is adopted as a correlation was found to be significant and positive amongst many variables, such as experience of an extreme weather event, perception of risk, and the ability to identify future climatic impacts responsible for the adaptation process. These variables were deduced from the participatory study findings and resultant hypothesis. The association of the adaptation process established through the regression analysis and the participatory study observation in line with the adaptation concepts outlined from literature review are explained in section 8.3.

In order to get a comprehensive picture of the adaptation process reported by the wider FM community and owing to the statistical assumption restriction on the data obtained (data gathered in this research is non-parametric and the dependent variable is dichotomous), a logistic regression analysis was performed. The variables considered for the regression analysis were fivefold:

1) Experience of a climate-related event;

2) Perception of climate change as a risk to an organisation's functions;

3) Identification of future climate change impacts on organisational functions;

4) Extreme event experience, resulting in examining future climate change impacts; and

5) Including climate change impacts in disaster recovery or future risk assessment.

These variables were regressed in three parts, resulting in three logistic regression equations. The amalgamation of these equations has formulated an adaptation process model, which confirms the findings of the participatory study carried out prior to the questionnaire survey. The equations are simplified below as follows:

- Climate-related extreme events experience (CE) + Perception of climate change as a risk (PR) = Identification of future climate change impacts (IM) ……………………(1)

- Extreme events resulting in examining climate change impacts (CIM) + Identification of future climate change impacts (IM) = Including climate change impacts in disaster recovery or future risk assessment (DR) ……………………………………………(2)

- Perception of climate change as risk (PR) + Identification of future impacts (IM) = events resulting in considering future climate change impacts (CIM) …….………….(3)

The first two narrative equations mentioned above constitute the adaptation process model fitting to the data gathered, while the third equation maintains the validity of the first two equations by establishing appropriate links in the model.

The reasons for establishing the model using two equations come from the assumption related to logistic regression. As per Field (2005), Pallant (2005) and Tabachnick and Fidell (1983), the data for multiple logistic regressions needs to fulfil the assumptions on multicollinearity sample size and outliers. These assumptions state that the variables in the regression analysis should be linearly correlated but not strongly correlated, that the sample size should be large enough to carry out regression, and that there should not be too many data points which do not fit the regression model. For sample size, Pallant (2005) states the formula $N>50+8m$, where N is the desired sample size and m is the number of independent variables.

In order to fulfil the assumption of multicollinearity and sample size, the model was constructed by using two separate logistic regression analyses and resulting equations.

8.2.2 Regression for establishing a mitigation model

The regression for mitigation action was carried out to fulfil observations from literature and the participatory-study organisation's approach to mitigation. It was observed that the present legislation, in association with corporate social responsibility (CSR) strategy (which is mainly driven by macro-level factors such as market standing), is responsible for much of an organisation's approach to mitigation; it is also affected by the resources available to the organisation (via organisational size). In addition, at an operational level, mitigation measures are constituted as a routine part of the FM strategy if they are deemed to be financially benefitting and are in accordance with the organisation's overall approach towards mitigation (driven by legislation and CSR).

Once again owing to the statistical assumption restriction, the regression is performed in two parts, giving rise to two separate equations. The variables and related equation are sixfold in this case:

1) Financial benefit resulting from the mitigation measures;
2) Addressing climate change within the organisation (taking action or doing nothing);

3) Taking mitigation measures as a routine part of FM strategy;

4) Organisational size (SME, multinational, etc.);

5) Legislative drivers; and

6) Strategic drivers (CSR).

The two equations these variables are regressed into are thus:

- Legislative drivers + Strategic drivers + Organisational size = Addressing climate change mitigation at an operational level ...…………………………………………….(4)
- Financial benefit resulting from the mitigation measures + Addressing climate change within the organisation = Mitigation measures form part of routine FM strategy..….(5)

These equations fulfil the first and second rationales mentioned in earlier paragraphs.

8.3 Statistical outcome of regression analysis

This section presents the outcomes of the regression analysis carried out in SPSS with the variables stated above. The model analysis for each equation is presented in Appendix 15 and is referred to further below. The results outlined below shows the variables included for each regression analysis having a bearing on each equation for cases of adaptation and mitigation. A comprehensive results table is provided for each test in order to gain an overall picture of the test carried out. The equations formulated through regression are mentioned at the end of each test and finally the model is formulated based on the association established through the equations. This is done for both mitigation and adaptation.

8.3.1 Logistic regression for adaptation

For the purpose of consistency a total of 106 cases (sample size for every regression test) from the private sector were selected. At any stage no more than two independent variables were included in the analysis, which fulfilled the assumptions both for multicollinearity and for sample size calculated through the formula quoted above from Pallant (2005). Thus for two variables we have sample size N given by $N > 50 + 8m$, where m is number of independent variables; so N needs to be greater than $[50 + 8(2)]$, i.e. $N > 76$. In the present case, $N = 106 > 76$. Thus the sample size assumption is fulfilled.

Although there is no test for multicollinearity for logistic regression in SPSS, Pallant (2005) and Field (2005) suggest use of a collinearity test carried out for multiple regressions. Thus to look for multicollinearity the variables were entered into SPSS's linear regression statistics test, and the test results are given in tabular form in Appendix 16. Once again as per Pallant (2005) and Field (2005), the variables with (various inflation factors) VIF>3.000 are known to be strongly correlated to each other and thus issues with multicollinearity can arise. However, there were no significant figures observed suggesting multicollinearity.

In spite of this, there were two independent variables which were not entered into the same test. These variables were assessed in consecutive complementary questions within the questionnaire study and were found to be positively strongly correlated with each other. They are:

- Climate related extreme-event experience; and
- Extreme events resulting in examining climate change impacts.

The dichotomous variables were given the value 0 and 1 for negative and positive responses respectively and with the ranked Likert scale responses the lower value represented a low score while a higher value represented a higher score. (e.g. 1= low agreement, 5 = complete agreement).

The first analysis carried out was for equation (1) above (see subsection 8.2.1). The independent variable (IV) was 'Climate-related extreme-event experience', where experience of such an event scored 1 and no such experience scored 0. 'Perception of climate change as a risk' was measured on a Likert scale, where 1 represented no risk perceived and 5 represented extreme risk perceived. The dependent variable (DV) was 'Identification of future climate change impacts', where the responses were converted to a dichotomous scale from the original Likert scale. The lower impacts identified were given value 0 while the major impacts identified were given value 1.

The complete regression analysis can be found in Appendix 15 section 1, and Table 50 below provides a summary of the statistical results achieved.

Table 50: Statistical summary for regression for adaptation equation (1)

	B(SE)	95% CI for odds ratio		
		Lower	Odds ratio	Upper
Constant	–2.05 (1.03)	-----	------	-----
Experience of an extreme event (CE)	2.61(0.82)	2.72	13.6	68.05
Perception of climate change as a risk (PR)	0.98 (0.30)	1.48	2.66	4.87

R^2 = 0.83 (Hosmer and Lemeshow), 0.24 (Cox and Snell), 0.39 (Nagelkerke).

The equation can be presented as

Logit(IM) = –2.05 + 2.61(CE) + 0.98(PR).

From this we can establish that experience of an extreme event and perception of future climate changes as a risk are significant predictors for identification of significant and major impacts and thus formulates the first part of our overall model, as shown diagrammatically in Figure 31.

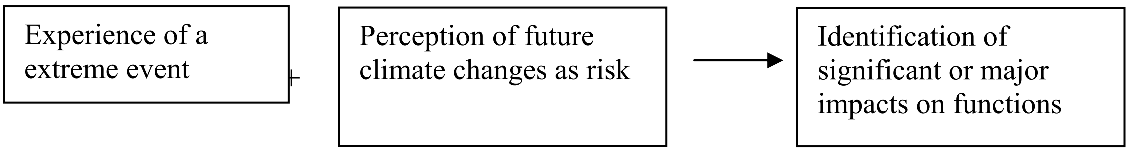


Figure 31: Regression equation (1) for adaptation, in diagram form

Equation (2) in subsection 8.2.1 helps to constitute the model further. Here the independent variables are 'Extreme events resulting in considering climate change impacts' (CIM) and 'Identification of future climate change impacts' (IM), while the dependent variable is 'Including climate change impacts into disaster recovery or future risk assessment' (DR).

All the variables are dichotomous, where the identification of future impacts has been converted from a ranked Likert scale to a dichotomous form. All the dichotomous variables have 0 representing a lesser score or negative response and 1 representing a higher score or positive response.

The complete regression analysis can be found in the Appendix 15 section 2 and in concise form in Table 51.

Table 51: Statistical summary for regression for adaptation equation (2)

	B(SE)	95% CI for odds ratio		
		Lower	Odds ratio	Upper
Constant	-0.65 (0.47)	-----	------	-----
Extreme events resulting in considering climate change impacts (CIM)	1.81(0.47)	1.28	3.25	8.24
Identification of future climate change impacts (IM)	0.45 (0.54)	0.53	1.57	4.62

R^2 = 0.53 (Hosmer & Lemeshow), 0.08(Cox & Snell), 0.12 (Nagelkerke).

The equation can thus be presented as

$$\text{Logit(DR)} = -0.65 + 1.81(\text{CIM}) + 0.45(\text{IM}).$$

From this the second part of the model can be organised, as shown in diagrammatic form in Figure 32. Here, it can be stated that an extreme weather event resulting in future consideration of climate change is a significant predictor for the inclusion of climate change in an organisation's disaster recovery planning and overall risk assessment.

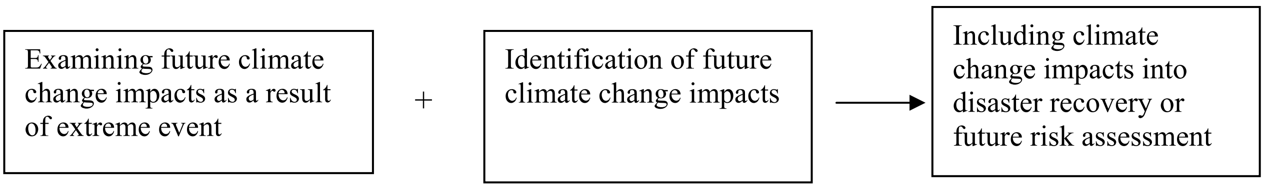


Figure 32: Regression equation (2) for adaptation, in diagram form

The third regression analysis is performed to complete the model and to demonstrate the valid link between the above two equations using equation (3) in subsection 8.2.1 above: Perception of climate change as risk (PR) + Identification of future impacts (IM) = Extreme events resulting considering future climate change impacts (CIM). The independent variables in this analysis were PR and IM, while the dependent variable was CIM. The independent variables were transformed to a dichotomous form from a ranked Likert-scale set of responses.

Appendix 15 section 3 presents the statistical outcomes of the logistic regression, which is also simplified in Table 52.

Table 52: Statistical summary for regression for adaptation equation (3)

	B(SE)	95% CI for odds ratio		
		Lower	Odds ratio	Upper
Constant	-2.02 (0.85)	-----	------	-----
Identification of future climate change impacts (IM)	1.76(6.93)	1.49	5.81	22.61
Perception of climate change as risk (PR)	0.12 (0.20)	0.75	1.33	1.69

R^2 = 0.91 (Hosmer & Lemeshow), 0.09 (Cox & Snell), 0.13 (Nagelkerke).

The equation obtained can be expressed as

$$\text{Logit(CIM)} = -2.02 + 1.76(\text{IM}) + 0.12(\text{PR})$$

Table 52 reveals that 'Identification of future climate change impacts' (IM) is a predictor of the consideration of climate change as a result of extreme event(s), as presented in diagrammatic form in Figure 33.

Figure 33: Regression equation (3) for adaptation, in diagram form

From this the link between the above two equations is set up, giving rise to the final model. The three equations obtained for the model are presented diagrammatically in Figure 34.

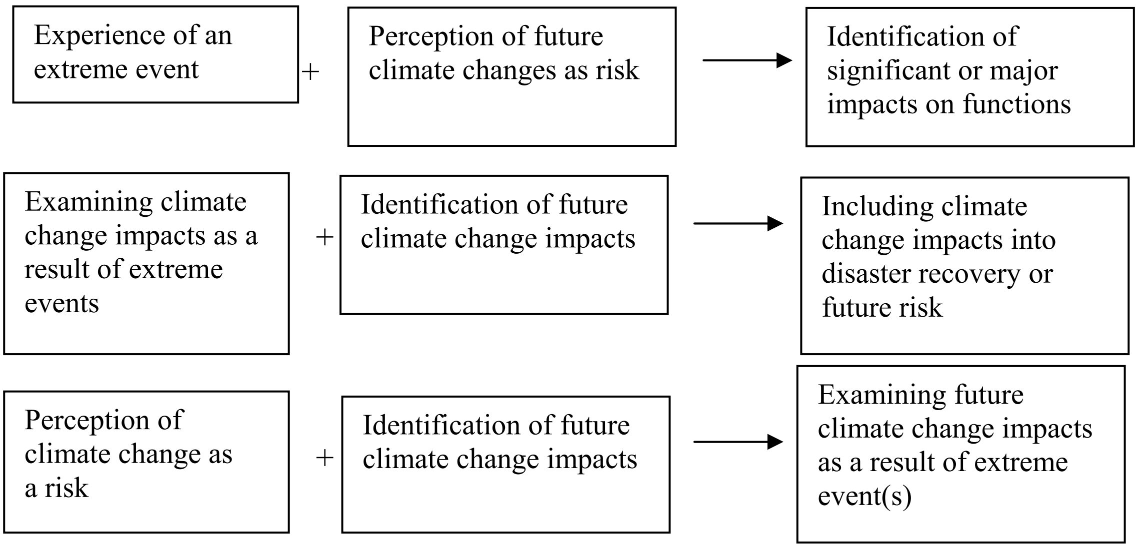


Figure 34: Combined regression equations for adaptation, in diagram form

The final model derived from these is presented in Figures 35 and 36.

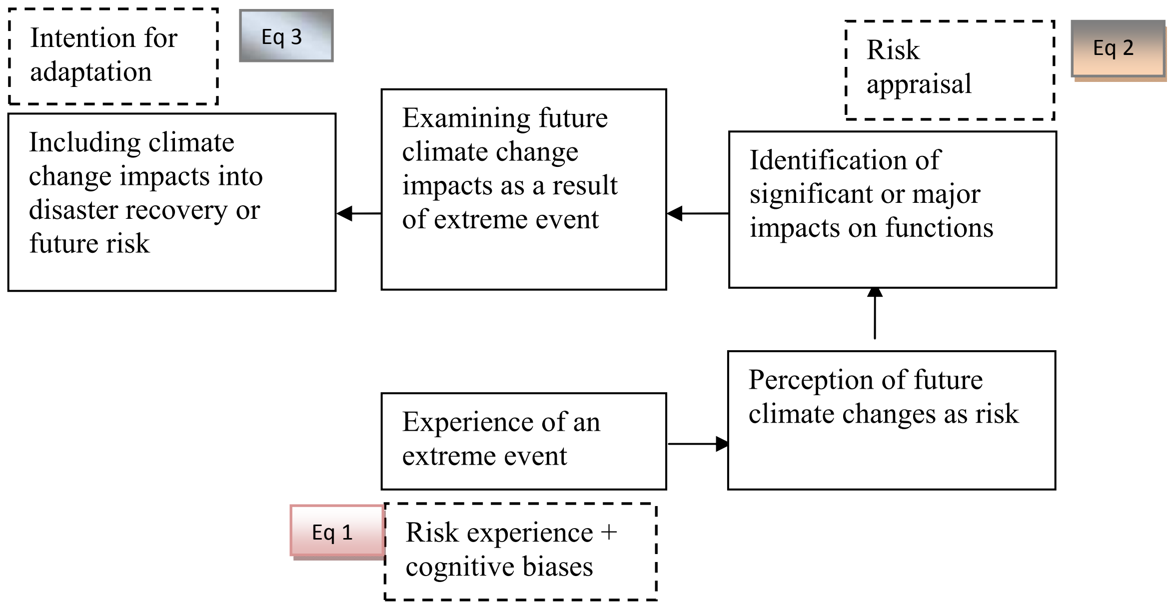


Figure 35: Adaptation process model derived from combined regression equations

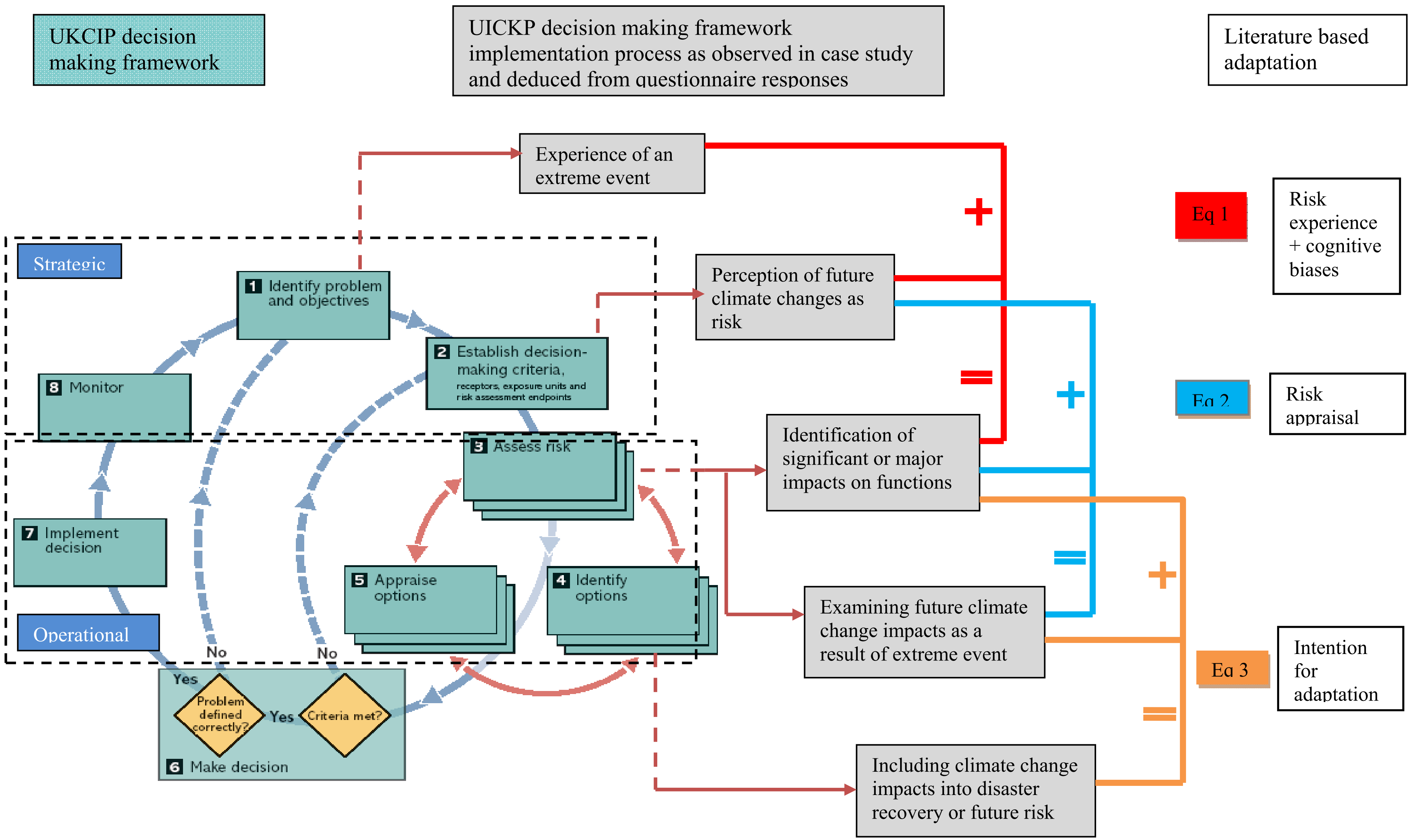


Figure 36: Adaptation process derived from the questionnaire responses and their association with the UCKIP decision-making framework and theoretical adaptation concepts

As mentioned earlier, the model is formulated by undertaking three logistic regression tests. This was to avoid issues with statistical assumptions of multicollinearity. In other words, the entire logistic regression process is being divided into three parts (performing three logistic regression equations) using the same variables.

The model formulated in Figure 36 reveals the components of the adaptation process explained in the next subsection. The model was found to be in accordance with the adaptation process observed from the participatory study and the adaptation concepts outlined in key literature. Chapter 9 elaborates these findings further.

8.3.2 The adaptation process

The adaptation process formulated by using logistic regression analysis is described in the following paragraphs in line with the sequential stages of the process.

1) Experience of an extreme event or the threat of financial loss initiates the strategic intention of adaptation and influences the first stage of the decision-making framework for identification of the problem and for setting objectives. This was observed in both the participatory study and the questionnaire responses – for example, in the case of the participatory study's financial services organisation an extreme event of flooding caused damage to the secured vaults and thereby significant financial loss, while overheating in summer months caused an increase in energy bills and staff complaints. This brought forward the strategic need to address future flooding and overheating, which was considered might increase due to climate change. The organisation's agreement to be involved with the research study for including adaptation measures in existing built-asset maintenance and management was thus a result of an experience of existing extreme weather event and related financial loss. The wider applicability of this concept was also found in the questionnaire responses, where the extreme event had an influence on the organisation's consideration of the future impacts of climate change. Thus the impact of the extreme event was found, through both the participatory study and the questionnaire survey, as significant for creating the first stage of the decision-making framework.

2) The risk perception of strategic personnel and the attitude to climate change influenced the second level of decision-making criteria within the framework. In essence, if the damage to the built assets or to crucial work processes had caused substantial financial cost or impacted

the public image or stakeholders' positive perception of the organisation, then the risk was perceived to be higher. This was due to the fact that the participatory study organisation was from the financial services sector and the stakeholders' confidence in their properties and functions was one of the critical success factors (CSFs). Thus the risk of failing to achieve that particular CSF was also perceived to be higher. This could also be said to be true about a larger private-sector sample, where stakeholder confidence would be one of the CSFs required to be fulfilled in most organisations. In addition, acceptance of climate change occurrence influenced the risk perception – i.e., the greater the acceptance of the climate change occurrence, the more rooted the risk perception of future financial or public-image loss. As a result, the risk perception related to the stakeholders' image and the organisation's CSF fulfilment influences the second stage of setting decision-making criteria in the framework.

3) The third stage in the framework, namely the assessment of risk, operates in FM operational realm and manifests itself at two levels. The initial level undertakes the screening of likely impacts, which are classified using a scale of minor to major against the criteria decided in earlier stages. This initial level is influenced by the combined effect of experience of an extreme weather event and the associated risk perception prevailing at strategic level. The second level of this stage examines the classified significant and major risks using the familiar semi-quantitative risk assessment. This second level of assessment in particular is initiated when strategic risk perception is supported by the prior filtering out of primary impacts.

At this third stage it was observed that although on the bases of qualitative evidence the argument for future climate changes causing more extreme events were accepted at a strategic level, the quantitative evidence and practices at operational level for generating adaptation options were not well grounded. The three reasons identified for this were: (a) prevailing uncertainty in projections, which were therefore difficult to quantify unless elaborate risk assessment methods were used – for which time and relevant knowledge were constrained; (b) at the time of the study the FM personnel had limited understanding of climate change data and its use, because the use of such data in their day-to-day working was minimal; and (c) one of the most important aspects of lack of quantitative assessment of impacts at the time of the study was the inconsistency between the business planning horizon of 3–5 years and the climate change projection horizon of 30 years – the future needs and expansion of every business could not be predicted or planned for 30 years' time because of various external forces. As a result, and after identifying the significant and major impacts of climate change, the facilities managers were unable to put forward a quantifiable assessment of those impacts for making the required financial case. The identification of the future impacts therefore reflects presently experienced impacts and the semi-quantitative approach tends to amplify the effect of existing known risk. This incremental approach of scaling up the known risk remains subjective, reflecting the facilities managers' beliefs and attitudes towards climate change projections.

4) Stage 4 of the process is influenced by the identification of impacts and further examination of the key impacts at stage 3; at stage 4, triggers were established keeping in mind the vulnerability and resilience of each built asset against the set business need criteria. Soft measures were then included in an existing business continuity plan (BCP) or disaster recovery plan, or insurance security is arranged. At the triggering of an alert, the BCP or disaster recovery plan is put into action. Hard measures of retrofitting are delayed unless the built asset is of importance in delivering the business services. In cases where recurring significant impact is observed, the built-asset value to business needs is assessed, in accordance with which disposal and major refurbishment decisions are taken.

5) Stage 5 of the process was not observed during the study period because its testing required the occurrence of a climate-related event, when the measures adopted could be implemented and then assessed for their success.

In summary, from the participatory study in the present research it is concluded that in that organisation's built-asset adaptation process, and in spite acceptance of the qualitative argument for climate change at a strategic level, the quantitative assessment of climate change impacts at operational level for building a financial case was missing. In this scenario, owing to the unavailability of short-term climate change projections (required in accordance with the business planning horizon), inherent uncertainty of the projection and lack of resources to carry out elaborate risk assessment processes, initial screening of the impacts is done and major impacts are examined later.

The examination of the impacts is carried out by amplifying known risk where the judgement is subjective and is influenced by attitudes and beliefs about climate change projections. Existing perception of risk, induced through experience of a climate-related extreme event, also influences the identification and examination of climate change impacts. In light of this, triggers are established keeping in mind the vulnerability and resilience of built assets. Soft measures such as insurance and a BCP are than adopted for built assets, bearing in mind their relevance to business needs. In the case of at-risk key built assets, hard measures through refurbishment have to be adopted.

The process observed in the present study reflects the concepts outlined in later adaptation research studies carried out at local-community level (e.g. the CREW (Climate Resilience to Extreme Weather Events) research programme described by Jones and Few (2009). The results in this quoted study revealed that the adaptation process at the local-community level consists of assessing future risk, which is based on existing known risk and experience of one or more climate-related extreme events. The vulnerability and resilience of local components is then checked against various criteria outlined. The lack of short-term climate change projections and a standard risk assessment procedure based on these projections gave rise to the resultant adaptation process.

The provision of short term climate change projections and risk assessment was found to be a resource-intensive task which was not always available at community level, just as in the case of a private-sector organisation such as the one focused on in the present study. Other results from adaptation studies reflected the comments made in the present study whereby the UK Government was encouraged to invest resources in producing short-term climate change projections and risk assessments of local areas on the basis of which short-term adaptation options could be selected. In light of the evidences from the present study, where certain levels of private-sector expectation of information from local government were detected, the provision of short-term climate change projections and attached risk assessments of local areas offered from central government would be welcomed by the private sector while they take steps to adapt to future climate changes.

8.3.3 Adaptation model association with adaptation theory concepts

The model obtained through the series of logistic regressions is regarded in this thesis as an adaptation process model. The model supports the process observed during the UKCIP decision-making framework implementation with the participatory study organisation and was also found in line with conclusions drawn in the literature (Risbey et al 1999, Berkhout et al 2004, Grothmann and Patt 2005). These also reflect various concepts for adaptation such as risk experience, risk appraisal, cognitive biases and heuristics, adaptive capacity and an intention for adaptation (explained in detail in Chapter 2 above). Indeed, the model presented in this study reflects the findings from Berkhout et al (2004) highlighting the aspects of organisational adaptation in the context of organisational learning on the one hand, while on the other hand it observes the importance of socio-cognitive elements in adaptation as presented by Grothmann and Patt (2005).

As per Berkhout et al (2004), organisations tend to adapt to changing climate in the same manner as adapting to technological or regulatory change. It is likened to the organisational learning process (see Chapter 2) but in the absence of definite but weak signals (i.e. slow or uncertain climate change effects), this learning is restricted. In this case a long-term adaptive approach is difficult to be conceived due to the ambiguous feedback loop.

Although extreme events can initiate some action, and possible changes in organisational routines are achieved to respond to the changes, they do not enable a long-term strategy for adaptation. Also, owing to weak signals, organisations involve themselves in the research and assessment driven from a higher level, which is affected by internal and external resources and marketplace conditions (covering, therefore, perceived and objective adaptive capacity).

The model conjectured from the participatory study and questionnaire in the present study affirms the observation made by Berkhout et al (2004), namely that the experience of an extreme event initiates a response and detailed procedural changes (in terms of strengthening BCP and risk assessment), further instigating risk perception and the screening of impacts – but it still fell short of enabling a long-term adaptation strategy.

Added to this are aspects of perceived adaptive capacity and risk perception recognised by Grothmann and Patt (2005) as socio-cognitive aspects that are important for adaptation and vulnerability assessment. The authors argue that subjective perceived adaptive capacity, cognitive biases and risk perceptions in relation to possible adaptation options are important socio-cognitive aspects affecting individual intentions of adaptation or adaptation decision-making. In line with this, the adaptation process within the participatory study organisation in this research observed that an extreme event occurrence with associated belief in climate change occurrence had been constituted as risk experience.

This had initiated risk perceptions and the identification of likely impacts for the purpose of risk appraisal. The perceived adaptive capacity of organisations (comprising knowledge, finance, and strategic support), in association with the perceived risk, formed the basis for adaptation (strengthening BCP, securing insurance, gathering local data, stringent maintenance activities etc).

A diagram explaining the association between the concepts in the aforementioned literature highlights and the model derived from the present study is shown in Figure 37.

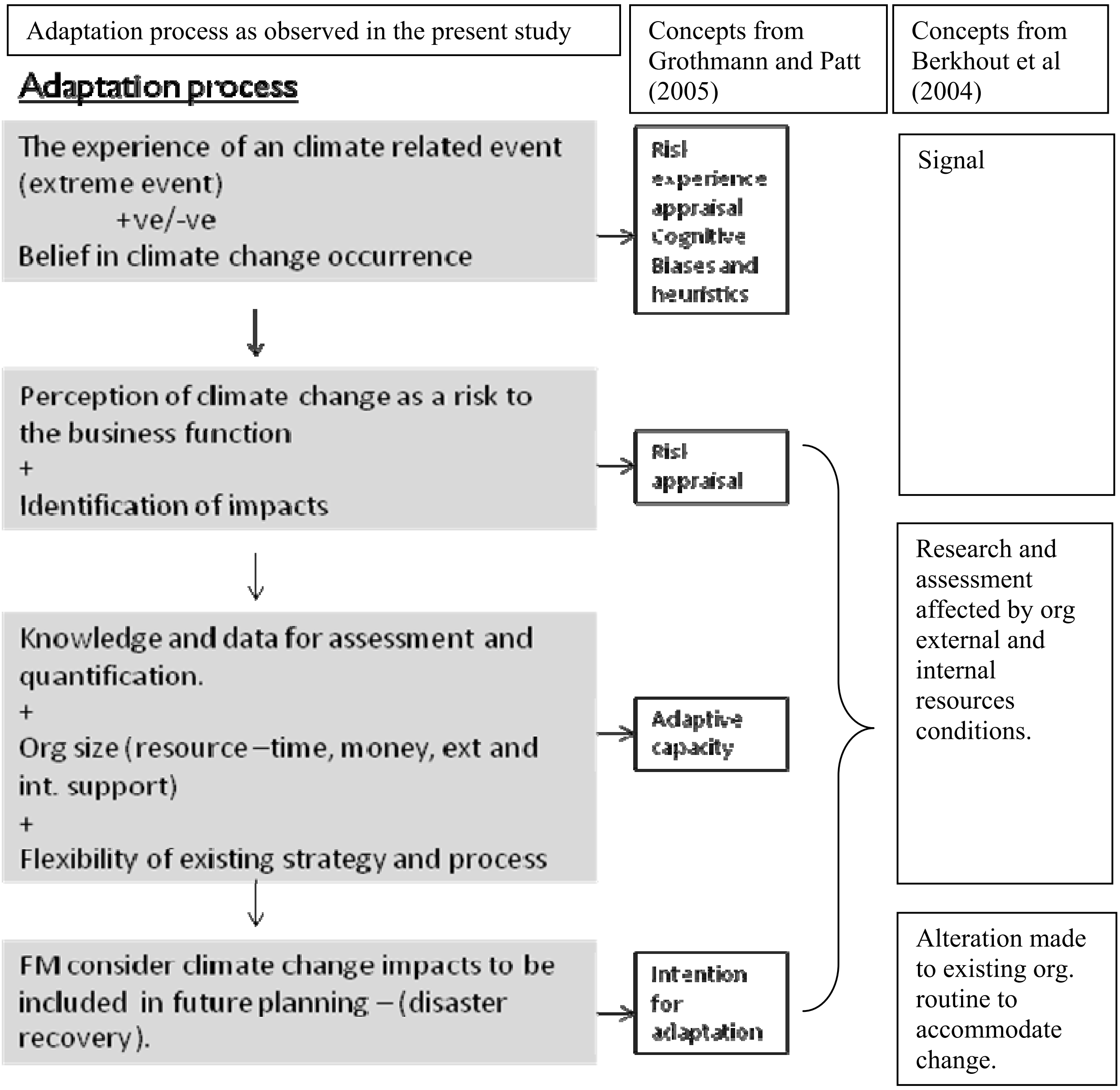


Fig 37: Association between adaptation process observed and literature evidence

8.3.4 The mitigation model

The results gained from the participatory study and literature stated that the existing legislation and corporate social responsibility strategy are two major drivers for an organisation's operational approach towards mitigation and are important in setting targets and budget provisions. The literature highlights similar findings, where inclusion of CO_2 targets are increasingly becoming part of CSR (Okereke 2007), which is used for managing stakeholder perception and competitive advantage.

Also, as a result of constituting a climate policy on the principle of ecological modernisation, a mix of market and legislative instruments are in existence nowadays offering a financial incentive for mitigation measures. As a result, companies can choose from various operational strategies depending upon their sector and countries of operation (Kolk and Pinkse 2005) to gain competitive and financial advantage.

In order to substantiate the observation made in the participatory study and from the literature, logistic regression was carried out considering the following six variables (see subsection 8.2.2):

- Financial benefit resulting from the mitigation measures;
- Addressing climate change within the organisation ;
- Taking mitigation measures as a routine part of FM strategy;
- Organisational size;
- Legislative drivers; and
- Strategic drivers (CSR).

The logistic regression was performed, first, to demonstrate that legislative and strategic drivers are responsible for the overall approach of an organisation to climate change. It was also hypothesised from the evidence from literature that organisational size (and thus the resources available) would help in taking mitigation measures forward. This is constituted as an equation thus (equivalent to equation (4) in subsection 8.2.2):

Legislative drivers (REG) + strategic drivers (CSR) + organisation size (ORG) =
Addressing climate change mitigation at an operational level..……………………..……..(4)

The second part of the regression analysis establishes that routine mitigation measures become part of FM strategy when they are encouraged by some financial benefit and when an overall organisational strategic target is set for emission reduction. This is presented by the equation (equivalent to equation (5) in subsection 8.2.2):

Financial benefit from mitigation measures (FMIT) + Addressing climate change at strategic level (ST) = Mitigation measures form part of routine FM strategy (MITROU) …………..(5)

For undertaking a regression analysis, once again the assumptions of multicollinearity and sample size were maintained. There was no multicollinearity among the independent and dependent variables. The sample size for the test was once again determined by using the formula specified earlier in this chapter for both tests: for first test there were three independent variables and for the second there were two independent variables present; and so sample size N for the first and second test is given by N>50+8m where m is number of independent variables and is set at 3. We have N>50+8(3), i.e. N>74. The sample size for both tests was in fact set at 99.

Equation (4) above was formulated by considering the following four variables out of the original six:

- Taking mitigation measures as a routine part of FM strategy (MIT);
- Organisational size (ORG);
- Legislative drivers (REG); and
- Strategic drivers (CSR).

The legislative and CSR drivers and organisation size were independent variables and were dichotomous in nature. Full statistics results are provided in Appendix 17 section 4, and Table 53 presents the summarised findings.

Table 53: Statistical summary for regression for mitigation equation (4)

	B(SE)	**95% CI for odds ratio**		
		Lower	**Odds ratio**	**Upper**
Constant	–0.83 (0.87)			
Legislative drivers (REG)	1.55 (0.47)	1.87	4.75	12.04
Strategic driver (CSR)	1.77 (0.75)	1.35	5.91	25.79
Organisation size – SME (ORG)	–1.04 (0.83)	0.069	0.35	1.81
Organisation size – corporate (ORG)	–1.53 (0.80)	0.04	0.21	1.04

R^2 = 0.84 (Hosmer & Lemeshow), 0.18 (Cox & Snell), 0.24 (Nagelkerke).

The test reveals that the only significant predictors of addressing climate change mitigation in an organisation are legislative and strategic drivers. Here the CSR impetus is believed to be driven by stakeholder demand and market standing. The organisational size is not found to be a significant determinant of the approach towards mitigation. It is suggested that, provided there is legislation enacted to force along the mitigation efforts, the companies would take action towards their fulfilment. This was also evident by the widespread opinion found in the questionnaire responses, where the respondents from both the public and private sectors believed that private-sector organisations would only curb their emissions in the presence of a strong Governmental drive and accompanying legislation.

The resultant equation of the analysis is as follows and is shown in diagrammatic form in Figure 38:

$$\text{Logit(MIT)} = -0.83 + 1.55(\text{REG}) + 1.77(\text{CSR})$$

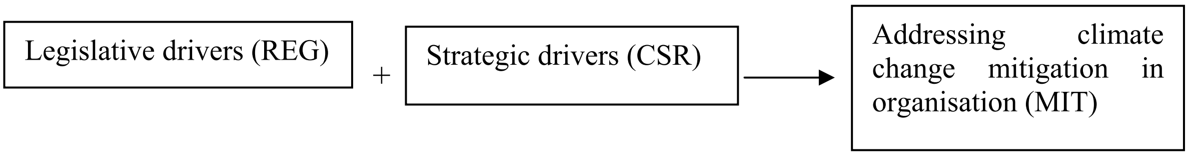


Figure 38: Regression equation (4) for mitigation, in diagram form

Equation (5) above was constituted using the four following variables:

- Financial benefit resulting from the mitigation measures (FMIT)
- Addressing climate change within the organisation (OP)
- Taking mitigation measures as a routine part of FM strategy (MITROU)
- Strategic drivers (ST).

All the variables were dichotomous in nature. The detailed analysis is presented in Appendix 17 section 5, and Table 54 summarises the results where the mitigation measures as a routine part of FM strategy is a dependent variable and the others are independent variables.

Table 54: Statistical summary for regression for mitigation equation (5)

	B(SE)	95% CI for odds ratio		
		Lower	Odds ratio	Upper
Constant	–1.06 (0.48)			
Financial benefit from mitigation (FMIT)	1.08 (0.47)	1.16	2.95	7.52
Addressing mitigation at operational level (OP)	1.03 (0.48)	1.08	2.81	7.27
Addressing mitigation at strategic level (ST)	0.91(0.48)	0.96	2.49	6.46

R^2 = 0.79 (Hosmer & Lemeshow), 0.17(Cox & Snell), 0.24 (Nagelkerke).

The significant predictors for taking routine mitigation measures are financial benefit and an organisation's approach to addressing emission reductions at an operational level.

The equation deduced from the above, and shown in diagrammatic for in Figure 39, is

Logit(MITROU) = –1.06 + 1.08(FMIT) + 1.03(OP).

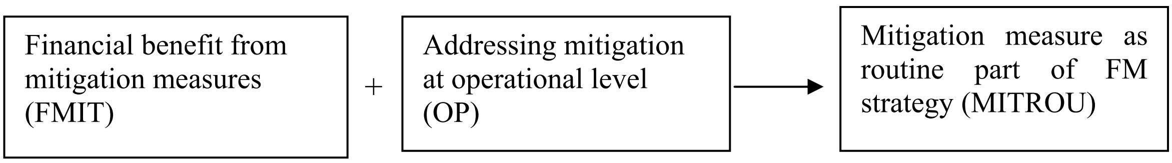


Figure 39 : Regression equation (5) for mitigation, in diagram form

As a result of the regression analysis for the purpose of defining predictors for mitigation action, other correlations established between variables related to mitigation action, and evidence from the participatory study and the literature review, the following model was constituted. The model represents a conceptual outline for mitigation action in a commercial context, where it is encouraged by legislation and strategic drivers such as CSR. The legislation is driven by the Government to fulfil national emission reduction targets, while corporate social responsibility is driven by an organisation's marketplace standing and stakeholder requirements.

In addition, the mitigation measures promoted operationally and forming a routine part of mitigation strategy were found to be related to financial benefits, indicating that FM strategy in the commercial sector tends to favour small operational measures which could be integrated into the routine maintenance cycle, such as installing energy-efficient consumables, checking supply-chain energy-efficiency credentials, and training staff. The organisations were found to be less favourable towards investing in measures such as micro-generation technology due to their long payback time, and the absence of a financial gain would restrict action to legislative requirements only.

Figure 40 represents the results of logistic regression carried out for mitigation action.

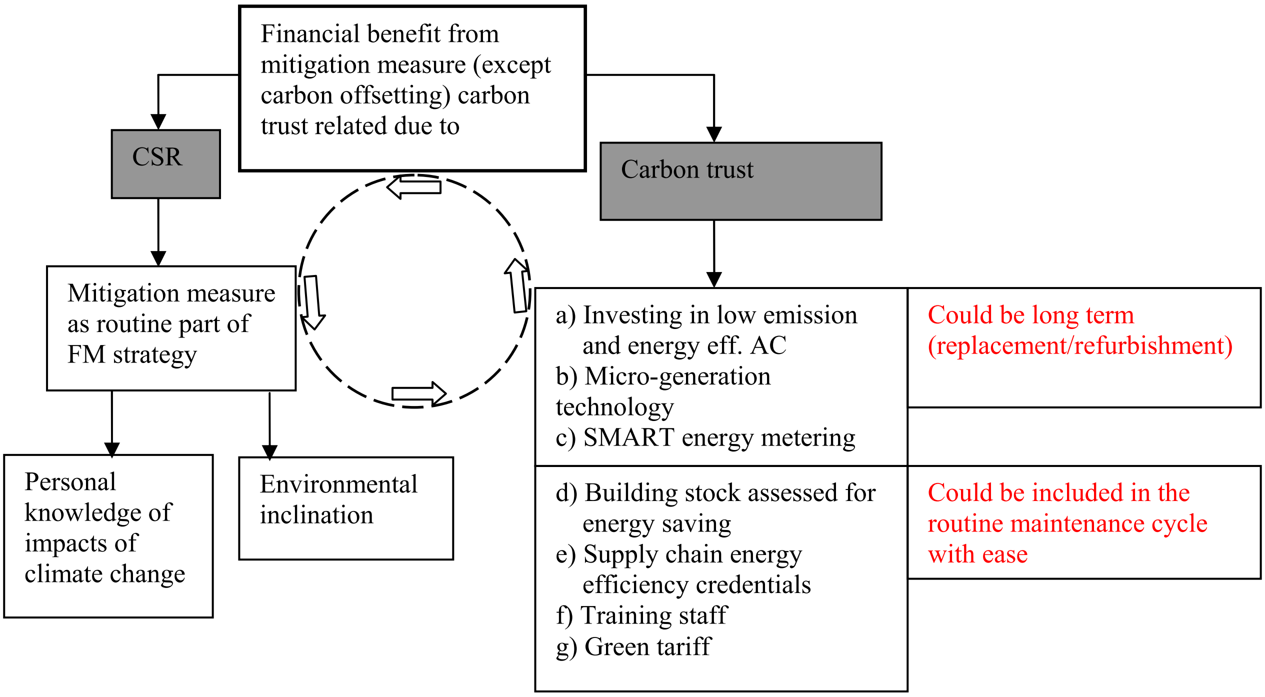


Figure 40: Mitigation action model derived from combined regression equations

It is necessary to keep in mind aspects of the above discussion that affect the initiation and decision-making processes for adaptation because these are essential to realising the adaptation process and can also make the process efficient by a deeper understanding of these aspects by better formulation of the process.

An organisation should create a team to deal with climate change which will have time, expertise and other resources to translate climate change projections into detailed impact analyses for the business functions and built assets, along with a quantitative risk assessment. Regard should be taken of any existing risk assessment method used by facilities managers in the organisation, in case such a method can be easily integrated and used across the entire built-asset portfolio. An assessment for near 10 years should be made using the new UKCIP09 projections at a detailed level irrespective of strategic support, while actions for promoting the strategic importance of long-term adaptation should be encouraged.

8.4 Chapter summary and discussions

In summary, this chapter outlines the logistic regression analyses carried out for both mitigation action and an adaptation process. The statistical assumptions and analysis tables are presented. The equation generated from each analysis, when combined, has resulted in a conceptual model which is to be regarded as a model fit for the response received from the small sample in the questionnaire. The results from the regression analysis and the conceptual model are found to be in accordance with the participatory study findings (observed case-study adaptation process) and the evidence from relevant literature (adaptation concepts and models).

Bearing in mind the UKCIP implementation process observed in the participatory study and the logistic regression equations derived from the questionnaire survey responses, two major conclusions emerge:

- Adaptation of private-sector built assets and their management is initiated only in the presence of the extreme weather event that has induced losses. This affects the first stage of the UKCIP decision-making framework – i.e., unless the event induces a financial loss the process of deciding on or actually initiating adaptation is not started.

- Facilities managers' perception and attitude to risk are very important and affect the decision-making criteria. The risk perception associated with experience of at least one extreme event allows the managers to proceed towards a serious consideration of significant and major impacts on their built assets and related functions, and this is undertaken during stage 3 of the UKCIP framework.

In summary, the constitution of these conceptual models identifies that adaptation lacks major drivers such as immediate financial gain and strategy shaped by legislation and thus is not a priority agenda for an organisation unless it has experienced financial loss due to climate-related events. In contrast, mitigation has gained a strong legislative drive with attached financial benefits.

The implementation and integration of mitigation measures in FM strategy is dependent upon the payback period of the implemented technology, while in the case of adaptation it depends upon the importance of the built assets to the business function in relation to the level of risk associated with climate change effects. For instance, if the built asset is of prime importance to the business with higher risk of future damage due to climate change, then physical measures to increase resilience would be planned; but in a case of lower risk, soft measures would be implemented. Built assets with lower business importance and higher climate-change impact risk would be attended to only in the presence of the occurrence of an extreme event, or similar triggers causing substantial financial loss.

Mitigation measures are easily implemented as the quantification methods for CO_2 calculations and reductions are now mainstreamed and are propagated by Government and various supporting organisations. Thus it is easier to adopt them in routine practices and does not require extensive knowledge of the science behind climate change projections. It is also possible to attach specific quantified targets for mitigation to a baseline emission scenario. These targets would be in accordance with a foreseeable short-term (five-year) strategic business-planning time line. These aspects make it easier to downstream mitigation measures to the operational FM level.

Unlike mitigation, for adaptation the essential method of risk assessment and quantification for implementing adaptation options is not yet standardised for sectors or for geographic regions. The risk assessment method is in turn a subjective choice in terms of the need of the level of risk to be addressed in particular case. These subjective choices are sometimes difficult to integrate with an organisation's routine practices and thus can hinder entire the adaptation process.

It is also difficult to attached any definite target to adaptation and plan for it within the foreseeable short-term business planning horizon, because the projection time frame of 30 years minimum does not reflect the maximum realistic time frame for strategic business and facilities planning (which is generally five years). Also, the projections for a climate change projection time frame of the next 30 years do not reflect major changes in climate variables which could heavily impact built assets. In this scenario it is the occurrence of extreme events that is likely to impact the built assets but there is a lot of uncertainty attached to such extreme-event projections at present. It is only recently, in the IPCC (2012) that the probability is being established of extreme-event occurrence being associated with climate change.

In such a scenario, adaptation has remained a reactive instead of a planned activity and one that has no compelling legislative driver or standardised assessment processes for businesses and facilities managers to adopt in their strategic framework. However, mitigation has become a planned, strategically intended activity which enjoys Government focus and support, and it is driven by legislation with established standardised methods for the targeted achievement of emission reductions.

From the results of the participatory study, the analysis of the supporting questionnaire, the availability of the projections and the current FM awareness, knowledge and attitude towards climate change adaptation, it has been suggested that until such time as site-specific short-term climate change projections are established, the impact assessment process based on the existing experience and knowledge of facilities managers should be favoured.

Facilities managers can use such assessment methods together with their past event experience and macro-level projections (UKCIP09 would be able to filter the likely impacts for their built assets), gaining additional help from semi-quantitative or elaborate risk assessment methods which are conducive to routine FM practices. The resultant assessments can then become a basis for gaining strategic support and for deciding on the near-term measures to be adopted for built-asset maintenance and management. There will be many organisational contextual factors affecting such assessments and adaptation processes within a commercial organisation, and these are discussed in Chapter 9.

Chapter 9: Conclusions and discussion

This chapter reviews the results achieved through the participatory study and the subsequent questionnaire work. It does this with reference to the initial research questions and objectives set in Chapters 1 and 2. The discussions below are related back to the literature review, where the results confirm or differ from the evidence given in previously published literature.

The chapter commences with a short mention in section 9.1 of the research question and objectives. Sections 9.2 to 9.4 discuss the achievement of the three objectives set for the study, while section 9.5 summarises the overall findings in the context of the research objectives.

9.1 Review of research question and objectives

The research set out with the aim of seeking answers to a central question: How can an existing risk assessment framework and climate change projections be applied to translate climate change impacts into built-asset-level risk to support long-term built-asset maintenance and management strategy?

The primary aim of the study was to develop an approach for a long-term climate-adaptive facilities management strategy, using existing tools (i.e. the UKCIP uncertainty and decision-making framework in the face of climate change) and climate change projections (UKCIP02 and UKCIP09) that ensure the ability of existing built assets to support their organisation's primary business functions in a cost-effective and sustainable manner.

The three objectives set towards fulfilment of the questions were:

- Identifying current FM approaches to CO_2 reduction (mitigation) and making building stock resilient (adaptation);
- Identifying issues related to the implementation of existing tools and climate change projections by facilities managers; and
- Identifying facilities managers' perceptions of mitigation and adaptation.

The next section discusses the results achieved from the methodology applied towards fulfilment of the objectives.

9.2 Objective 1 – Current approaches to mitigation and adaptation

This objective was intended so as to obtain an overview of the existing scenario of mitigation and adaptation prevalent within the participatory organisation and in the wider commercial sector. The case study organisation's relevant strategic documents, informal discussion and follow-up questionnaire work helped towards achievement of the objective (see particularly Chapters 4 and 7).

The key observation made was that addressing mitigation aspects differs with in which sector the company belongs to, while adaptation measures were carried out only after the experience of an extreme weather event in the majority of cases (although the relationship between extreme weather events and climate change was questioned and has only recently been established by the IPCC 2012). With emissions only from office energy use in the service sector, the measures include a mix of technical and behavioural factors. These are in turn to be read in the context of internal and external factors such as finance, legislation and stakeholder relationship management.

In the participatory organisation, and as found through the wider literature study, climate change has been considered a part of a wider sustainability strategy, and associated with energy efficiency measures. A targeted reduction in CO_2 emissions is set for annual or longer time periods. As a result, the environmental strategy of the participatory organisation had achieved its 5% reduction target by 2005 compared with a 2000 base level; further, it had met additional 5% reduction by 2010 from the 2005 level. Most of these reductions were achieved through both technical and behavioural measures.

9.2.1 Mitigation measures

The participating organisation achieved the reductions reported in the subsequent carbon disclosure project (CDP) and environment policy through renewable energy contracts with energy suppliers where CO_2 emission reduction was to be achieved at source. This produced financial gains, which were strategically favoured and which reduced the intended emissions from business functions.

In addition to procuring renewable energy contracts, the participating organisation implemented a wide range of easily implemented mitigation measures for its existing building stock during regular maintenance cycles. These included enhanced building controls, additional metering, solar-gain reduction and energy-efficient lighting. Measures such as low-emission high-efficiency boilers were introduced at the end of the life cycle of appropriate plant. Options such as wind power generation and enhanced insulation and glazing initiatives were strategically evaluated and applied only at selected sites. It was only in new builds and major refurbishment projects that measures such as heat reclamation, enhanced building management systems, internal lighting-control systems, centralised utility metering technology etc. were implemented.

Such measures were also reported by the wider FM community, where the following were implemented:

- Building stock assessment for energy saving;
- Staff training;
- Procure efficient AC systems;
- Energy-efficient consumables (e.g. low-energy lighting);
- Energy credentials checking within the supply chain; and
- Green energy suppliers/tariffs.

Behavioural change was instigated through training, through setting up sustainability management teams and through issued guidance. Encouragement was given to use video- and audio conferencing and rail travel links to reduce emissions.

It was observed that the mitigation measures prevalent in the private sector were ones which were easily implemented and did not require major refurbishments to the stock. This is in confirmation of the evidence from the literature, where Ekins and Etheridge (2006) have insisted that inclusion of renewable energy procurement and setting lower CO_2 reduction targets have encouraged managers (through potential financial gains) to implement simple energy efficiency measures. Even so, three measures were found not to be favoured in the private sector: (a) generating their own renewable energy; (b) considering carbon offsetting; and (c) investing in retrofitting micro-generation technology.

In consideration of the overall approach of the commercial sector to climate change, an incremental path in addressing energy efficiency and mitigation was traced from the questionnaire responses, whereby the initial energy efficiency and recycling measures resulted in implementation of Environmental Management System standards, which then led on to strategic carbon reduction targets and the achievement of these targets through on-going external consultation (see Chapter 7). These consultations were largely found to be involving the Carbon Trust and BREEAM certification.

9.2.2 Contextual factors/drivers to mitigation

The implementation of mitigation measures in the commercial sector are contextualised with respect to three factors, namely finance, legislation and stakeholder relationships. These could all be recognized as policy and behavioural drivers. Each is described further in turn below.

The results from the participatory study and questionnaire analysis revealed that financial efficiency within mitigation measures is key to their implementation. This is partly attributed to the principle of ecological modernisation, which is the basis for the UK Government's mitigation policy, and this implies an increase in energy efficiency to lower emissions and thus a saving in energy costs to businesses (see Chapter 2, Section 2.3.2).

The respondents from the participatory study asserted that any mitigation measure implementation should be financially viable, i.e. the capital cost should at least be outweighed by the on-going operational cost over an appropriate time period and the resulting emission reduction should be contributing towards legislative requirements. The results from the questionnaire survey also reflect these views, because a correlation between financial gains reported from mitigation measures and their consideration as a routine part of FM strategy showed a positive relationship while the number of multinationals reporting continual implementation of mitigation measures was higher than the number of SME and corporate organisations (although this was partly attributed to the financial resources available to such companies).

The importance of the financial aspect for facilities managers in implementing mitigation measures is related to the budgetary constraints faced by them because maintenance activities account for around 90% of outgoings on balance sheets, which makes cost savings an imperative for facilities managers and maintenance functions (Junnila 2004, citing Leibowitz 2001). This is also associated with the view that the maintenance and management of facilities is a technical project where fixed assets appear on the balance sheet and expenses related to their upkeep need to minimised (Alexander 1998).

Representing a similar point of view on the financial aspects of climate change mitigation, the Property Advisory Group's annual report, (DCLG 2000) has asserted the higher priority given to value for money over ethical issues in addressing sustainability of commercial stock – which were only altered due to external pressures from customers and environmental audits.

The mitigation action of the participatory study organisation and responses from the questionnaire were partly a response to the existing legislation affecting the UK commercial sector, where a financial gain was sought in complying with legislation, representing a win–win scenario.

There was a differentiation (identified mainly through questionnaire) between commercial/-private-sector and public-sector responses to the existence of legislation. The public sector was affected by a code of practice for sustainable homes development dating from 2006, by the Decent Homes programme 2001 and by Eco Homes 2006, which meant that public bodies were seeking additional resources to help to achieve the standards set by the legislation. In contrast, the private sector is affected by the climate change levy (CCL), introduced in 2001, climate change agreements, the UK Emissions Trading Scheme 2002, and carbon reduction commitments 2010 – all of which had one or other mechanisms for financial gain attached to them in the form of a tax rebate or the selling of carbon credits.

This is partly because these pieces of legislation are based on a policy emerging from the adoption of ecological modernisation principles where a win–win premise is of importance. The only exceptions to these were the Building Regulations Part L (2006) and Energy Performance Certificates (for commercial builds) 2008, which were also an area of concern for the participating organisation within this study and for respondents to the questionnaire survey, where these two sets of regulations were cited as prominent drivers for mitigation actions.

As a result, the services sector was driven to implementing relatively non-invasive and easily procured existing energy efficiency measures, resulting in legislatively required mitigation standards being met. This approach was also seen by Ekins and Etheridge (2005), who state that the inclusion of renewable energy procurement, rebates of corporate tax from the CCL, and agreement of reasonably lower CO_2 emission levels set by the CCA has led to managers' willingness to implement existing technology for energy efficiency – which was not the prior case owing to a lack of both motivation and potential financial gain.

Procuring renewable energy contracts was a favourable measure for the participatory study organisation as it offered them national insurance contribution (NIC) cuts as per CCL implementation. This was also evident in the wider commercial sector's FM strategy – for instance, the CBI's 2002 survey reported that larger service sector organisations had benefited from £417.7m in NIC reductions, against £356.1m paid in CCL, yielding a net gain of £61.6m.

In light of these research findings and the literature evidence, it could be suggested that legislation-driven mitigation measures have been to some extent successful owing to the financial aspect in the service sector, with adoption of easily implemented mitigation measures. This has also resulted in an improvement in service sector perception relating to climate change legislation and policy: Dunn (2002) explains how *"the financial and services sectors see relatively little legislative and policy risk than the industrial and energy sector."*

Business communication of the human, environmental, social and economic impacts of climate change and their effect on organisations through their approach to CSR have been of importance in managing the stakeholder relationship for businesses around the world. At the present time the communications within CSR on the environment have included mitigation targets and reduction measures (Okereke 2007). My research has found that the participatory study organisation was participating in FTSE 4 Good, the Dow Jones sustainability reporting and the carbon disclosure project as a means of taking forward CSR – all of which were also found be drivers for the questionnaire respondents for taking mitigation measures.

It can be concluded that participating in voluntary reporting initiatives is one of the preferred ways for the commercial sector to enhance its communication and maintain a robust stakeholder relationship. This in turn drives the mitigation strategy within the organisation, as voluntary reporting requires a set level of data gathering and management of CO_2 emissions along with efficient mitigation strategies. The evidence from the literature is along similar lines, where Arora and Cason (1996) and Stoeckl (2004) assert that the formulation of CSR, an environment policy and environment impact management has become one of prime importance to businesses and industry, which in turn take on voluntary reporting to manage their corporate image among customers and stakeholders, gain competitive advantage and adhere to ever-increasing legislation.

9.2.3 Adaptation measures

Historically, mitigation measures have had greater importance than the adaptation at both international and national level. This is also reflected in the private-sector response to adaptation.

It was noted during the participatory study and the UKCIP decision-making framework implementation process that, in absence of legislative or other drivers, adaptation took the shape of the implementation of building resilience through known processes and measures such as business continuity planning and disaster risk management. Confirmations for the claim are found in Wittneben and Kiyar (2009) and Warren (2010). Many of the measures were 'no regret' in nature, where insurance terms were secured for the properties at risk from flooding or that had experienced past weather-related flooding events – although the strategy of securing insurance will not be possible after the Association of British Insurers' agreement with the UK Government to provide insurance cover for flood-prone sites comes to an end in 2014. A small number of physical measures were planned at high-risk properties, to be implemented at the next possible refurbishment cycle. These included replacing carpet flooring with hard surfaces, getting lower-level electrical connections above the flood line, and considering responsive landscaped areas around the site which help in draining water quickly. Once again implementation of these measures depended upon making a business case to achieve the financial support for these actions.

Adaptation was sought against flooding and overheating events. In cases of flooding, it was observed that much of the information and guidance was sought from the local authorities as some of the actions were thought to be not in the hands of the organisation itself. This is also been pointed out by Stern (2006), suggesting that in many instances physical adaptation measures would not be possible to accommodate within private-sector adaptation boundaries. In cases of overheating, there was not much physical intervention made as the overheating events occurred over shorter time periods, but these were quickly becoming areas of concern due to recurrence during consecutive summer periods. The measures taken were most of the time temporary in nature, such as installing air conditioning and chillers; this in turn had an impact on the CO_2 emissions strategy. For larger organisations this was not an area of much concern as securing recurring renewable contracts enabled both the CO_2 emission and financial aspects to be addressed.

The process of adaptation observed with this study's participating organisation was influenced by its cultural and structural dimensions and reflected an association with wider adaptation concepts. These were found to be in accordance with existing literature evidence (Berkhout 2004; Grothmann and Patt 2005; see also Chapter 8). In addition, the adaptation process was observed to be like that experienced by organisation learning, as noted by Pelling et al (2008) and Wilby and Vaughan (2011) (see Chapter 2).

It was noted that the factors affecting/driving mitigation (legislation, financial imperative and stakeholder relationship) were absent in cases of adaptation because, at the time of this study (2005–07), there was no major legislation on the UK statute book to push forward the issue of adaptation, especially with regard to the private sector. Initiatives in public-sector adaptation only included the so-called Nottingham Declaration 2000, which was an informal declaration by local authorities to be involved in responding to climate change.

The newly introduced Climate Change Act 2008 once again addresses climate change adaptation at national, regional and local-authority levels where community level adaptation is addressed. A legislative initiative requiring adaptation action in the private sector (private adaptation) is missing. In the absence of such a driver (an external signal) the private sector, driven only by financial and business factors, is likely to take some action to adapt only after it has had experience of an extreme weather event that has caused significant financial loss. In such circumstances the extreme event occurrence, although not directly related to climate change, works as an imperative to take action involving altering existing organisational routines. This has been confirmed by both observation within the participatory study and by the questionnaire survey, where an extreme event experience was found to lead to considering future climate change impacts, followed by a reasonable amount of attention being given to such issues in the organisation, depending upon its size and the sector in which it operates.

The recent 2010 Ipsos MORI survey into public- and private-sector awareness action has put forward similar results, confirming that many participative organisations lack a financial imperative to take any action and are less aware of, or concerned about, climate change adaptation issues as a result.

9.3 Objective 2 – Identifying issues related to the implementation of existing tools and climate change projections by facilities managers

The fulfilment of Objective 2 was achieved through the participative case study presented in Chapter 5, where results for each stage of the UKCIP decision-making framework are presented. This current section is a summary of the key issues related to the implementation process and the final results from it.

The key issues identified during the implementation process dealt with the internal aspects of the participating organisation, the uncertainty attached to projections, and routine FM practices. In particular they could be described as follows:

- Projections and guidance:
    - Uncertainty attached to projections, and unavailability of micro- (site-) level projections and data on local conditions; and
    - Nature of decision-making guidance.
- Organisational aspects:
    - Financial management constraints;
    - Low climate change data familiarity amongst facilities managers;
    - Lack of property-level (micro-level) data availability, especially in the case of newly acquired property;
    - Lack of availability of time and resources for implementation of elaborate quantitative risk-assessment methods (risk assessment methods used by facilities managers tend to be that of hazard assessment in relation to health and safety regulations);
    - Shorter planning horizons for some businesses (especially in the service sector), where the driver of change in such organisation is market and product-success dependent. The initial 30-year time series (2011 to 2040) projected very small changes in climate variables when compared with the observed baseline period (1969–90); and
    - Organisational structure and learning.

9.3.1 Projections and guidance

The participatory organisation had used the UKCIP02 projections and the UKCIP decision-making framework in the face of uncertain climate change in order to achieve a long-term climate-change adaptive strategy for that organisation's built assets (see Chapter 5). During the implementation process in assessing the qualitative and quantitative risk of flooding and overheating, the UKCIP02 projections were referred to.

The issues related to projections were related to the lack of availability of site-specific (micro-level) projection and uncertainty attached to the long-term projections. Although UKCIP02 gives projections based on a regional model at 50km resolution, based on daily outputs over four major UK areas (Scotland, Northern Ireland, South East England and South West England), it lacked the sub-regional and local-scale outputs for variables such as rainfall and temperature which are important for impact assessment. The lack of such micro-level data for future risk assessment has also been expressed by Salagnac (2007) and O'Brien et al (2004). Although statistical downscaling and weather generating tools could have been used for quantitative risk assessment, the resource and existing-knowledge boundaries of the organisation constrained this process.

The UKCIP02 projections also had two types of uncertainty attached to them: emission uncertainty and scientific uncertainty. These uncertainties have been addressed with the aid of expert judgements, as measured against a confidence scale of high, medium and low assigned to the individual projections based on physical reasoning, consistency between various models and statistical significance of the results (Hulme et al 2002). These are not absolute or probabilistic judgements.

Dealing with such treatment of uncertainty and long-term average projection was difficult for the FM team as it only helped in the qualitative and semi-quantitative screening of risks and an outline of their impacts on their built assets and functions. This also proved to be less helpful towards future planning and making a business case, as these require definitive outcomes for allocating financial resources. Findings similar to this have also been cited in the recent Ipsos MORI 2010 survey, which stated that organisations wanted to know what the effects of climate change would be (not what they might be) and to understand their relevance to them.

The recent UKCIP09 scenario addresses some of these concerns as it provides data sets over a 25km grid over the entire United Kingdom, which is subdivided into regional legislative boundaries and areas. The scenario also addresses the uncertainty aspect by providing probabilistic projections at 10%, 33%, 50%, 67% and 90%, which indicate the likelihood of projected change being at or less than the change from the baseline (1961–90) period. UKCIP09 also presents projection over 30-year overlapping time periods – 2010 to 2039 containing the 2020s; 2020 to 2049 containing the 2030s; 2030 to 2059 containing the 2040s, and so on. Information such as this allows for shorter time periods to be considered.

During the latter stages of the implementation process for a decision-making framework by the participating organisation's FM team, they found the guidance on climate change lengthy and complicated owing to its recommended use of UKCIP02 projections for quantitative assessment. The initial stages of 'Identifying the problem and objectives' and 'Establishing decision-making criteria' were easy to follow for the FM team to undertake the qualitative risk screening (tier 1 stage 3) of the impacts on their selected properties (i.e. their at-risk properties as per Environment Agency maps). However, later stages were found to be complex.

Reporting findings on similar lines from surveys of public-sector use of information provided by UKCIP on climate change in primary years, and in spite of more accurate and freely available data, Demeritt and Langdon (2004) have cited 'technical–cognitive and practical–temporal' difficulties in accessing and understanding official sources of climate change information, and practical relevance of the administrative functions as a limitation of use of such data and guidance for addressing climate change in local authorities.

Further comments made on the nature of guidance by DEFRA in the UKCIP 2004 review agree with the present research's findings, stating that the guidance is probably still too long and complex for direct use by many stakeholders (especially for decision makers) – although it did provide a comprehensive methodology. Such comments have been supported by the UKCIP new supportive guidance (Brown et al 2011) by highlighting the findings from an unpublished DEFRA report from 2007 that the tool guidance has been used by limited groups of stakeholders and that, in spite of being regarded as useful, it has not achieved wider take-up.

It has also been suggested that the unpublished report from 2007 has had a mixed response, receiving significant credit in the adaptation community (e.g. IPCC, Stern Review, Australian Greenhouse Office) at one end of the scale while being criticised at the other as difficult to understand due to its technical detail. This reflects the varied use by stakeholders and the inherent difficulty in communicating adaptation to a wider audience. Indeed, recent use of this guidance by local authorities (for impact assessments towards completion of NI188) and selected private-sector organisations (see www.ukcip.org.uk/case-studies) suggests diversified use of this guidance and tools derived from the same source (such as BACLIAT, and the UKCIP Adaptation Wizard).

In summary, it observed that in spite of the somewhat complex nature of the available guidance it was successful in generating wider awareness and concern towards adaptation within the FM team, who were ready to take the initiative and make adaptation issues visible at a strategic level.

9.3.2 Organisational aspects

The organisational factors such as available finance, expertise, time, decision-making skills, partnering ability and the influencing of market forces (and others) affected the implementation of the UKCIP decision-making framework (which is described in Chapter 4). These factors in turn define the inherent adaptive capacity of an organisation (see Chapter 2 for an explanation of ‘adaptive capacity’).

The implementation of the UKCIP decision-making framework was a new process which required organisational learning to ensure survival in the face of particular vulnerabilities within the organisation, which in turn reflects its increased adaptive capacity and resilience. Some of the organisational aspects affecting the implementation are described in more detail in the rest of this subsection.

Since the organisation was a large financial services group based in the United Kingdom, it possessed robust financial capability for initiating adaptation action; but this financial capability was found not to be channelled down to the lower tiers of the organisation. This pointed towards a hierarchical and somewhat authoritative management structure which took minimal note of suggestions from lower-level operational teams. This was evident from the implementation process, as the FM team was able put forward a qualitative/semi-quantitative analysis which could not become a firm basis for making a business case for adaptation, leading to little financial consideration given to any new adaptation options and especially physical interventions. On-going soft measures for adaptation were favoured by the strategic team (i.e. insurance cover and strengthening business continuity planning). Physical intervention was only considered in very high-risk sites where some extreme weather event had already caused financial damage. Here too the initial cost and return on adaptation measures were required to be justified by the team to secure the finance.

The resources for undertaking more data collection and training in quantitative methods for some members of the FM team were also curtailed. The subsequent questionnaire survey in the research study also highlighted a lack of resources and the importance of aspects other than climate change as influencing factors.

A lack of expertise in the use of climate data in the risk assessment process was also apparent. This was observed to be the case partly due to managerial unfamiliarity with climate change data as the managers' daily routine does not involve such data use and interpretation. The lack of awareness was also found in the wider FM community as, in spite of reporting awareness of climate change, the respondents to the questionnaire were not aware of, or involved with, the adaptation initiative requiring a basic understanding of climate change projections.

This aspect is also stressed by Willows and Connell (2003), suggesting that familiarity and working with climate data would help towards the assessment process. To deal with this unfamiliarity, the team had depended upon generic projections and tried-and-tested methods of assessment, including past experience and human judgement (as presented in Chapter 7).

The further tiered stages of the UKCIP decision-making framework involved suggestive use of quantitative assessment depending upon data availability, but there was a lack of property-level detail and projections and a lack of time and financial resources for employment of the elaborate risk-assessment methods. It is also to be noted here that FM practices usually involve assessing hazard risk (as per required health and safety law, which although it adopts similar principles of risk assessment, lacks long-term planning and quantitative scientific climate-projection use.)

For all organisations the strategic decisions are reflective of the marketplace it operates in, and this was no different for this study's participatory organisation. As a result of market-dependent business decisions, the organisation had acquired a large amount of built-asset stock in a very short time span. The dependency on the marketplace also meant that properties were acquired or sold frequently, and in many instances leased or rented, reducing considerably any imperative by the organisation to invest in improvement measures. This situation also had an effect on the ability of the FM team in terms of time and available human resources to manage the detail records of the properties, in turn affecting the later stages of the quantitative risk assessment process. The influences of external market forces were also evident in the overall approach to climate change within the organisation, whereby stakeholder concern for mitigation action was given precedence over adaptation.

A shorter business planning horizon for the organisation is also a result of market dependency for particularly the participatory organisation, as the organisation operates in the financial services sector which is highly volatile and depends upon gain or loss from short-term opportunistic decisions. The existence of long-term planning horizons is limited compared with its short-term decisions. The influence of these factors was evident on FM actions for climate change because the maximum planning horizon for FM was restricted to five years, from which annual reviews and budgeting had to be derived. As a result, long term projections (20–30 years) and uncertainty were difficult for facilities managers to comprehend and translate into short-term impacts.

The 2010 Ipsos MORI survey has outlined similar results, suggesting that the commercial sector as a whole is looking for information on short-term impacts rather than long-term changes.

Organisational learning and resilience are useful concepts (see Chapter 2) that have been applied for climate change adaptation in both the public and private sectors (Boyd and Osbahr 2010; Linnenluecke and Griffiths 2010; Wilby and Vaughan 2011). During the participatory study, observations were made in the context of these concepts.

There exist many definition of resilience, but that from the IPCC gives it (in short) as the ability of a system to maintain its original state in the face of external stresses and pressures; in other words, it is the capacity of self-organisation and adaptation to change. In the present study the participating organisation maintained its original state in the face of uncertain future climate change impacts by adapting to a new decision-making framework, through which it encouraged organisational learning. This learning led to an improved understanding of the organisation's existing adaptive capacity and of areas where more input was required. It in turn increased the organisation's resilience by strengthening existing strategies (BCP) and making interventions where required. These strategies were based on existing knowledge, available resources and experience (adaptive capacity), and they were kept flexible in nature so as to be adaptive to any future changes in external or internal conditions.

The process of learning observed in the organisation was congruent with the evidence found in the organisational learning literature outlined below. The literature claims four things:

1) Learning happens in response to an external threat or problem (Argyris and Schön 1996; Wang and Ahmed 2003). The organisation decision for involvement with the research and implementation of the decision-making project was based on the experience of financial loss due to an extreme weather event at one of the properties, and it was a common consensus that such an occurrence might increase with climate change, posing a threat to many other properties and business functions within the entire property portfolio.

2) Learning for adaptation and increasing adaptive capacity has to be 'double loop' learning (Kloot 1997, citing Senge 1990). The organisation had achieved so-called 'single-loop' learning during the research study as it had learned to use and alter existing processes and strategies thereby ensuring continuous survival. It still had to achieve 'double loop' learning, where generative learning leading to a paradigm shift occurs. This would have probably been said to be achieved when the capacities for assessing the future impacts on the business would be enhanced, leading to strategic importance given to the adaptation agenda and making climate change impact assessment and adaptation part of every business system.

3) Learning involves various stages, such as knowledge acquisition, information distribution, information interpretation and organisational memory (Kloot 1997). This principle was translated by Berkhout (2004) as signal recognition and interpretation, experimentation and search, and knowledge articulation and codification. The participatory organisation adopted these stages in its learning process where the initial experience of an extreme event is cited as signal recognition and is perceived as a threat or risk. This was followed by the stage of knowledge acquisition, distribution and interpretation (experimentation and search) where the UKCIP decision-making framework was implemented and the data on property in the portfolio and climate projections were gathered in order to undertake possible impact assessment.

   This semi-quantitative assessment guided the adaptation options such as strengthening the existing business continuity plan for at-risk sites (BCP review and alteration), including required physical intervention in the next possible refurbishment cycle of the property, and organising regular maintenance checks for at-risk properties. The measures also included looking for soft measures such as securing insurance before they ceased to be provided in the market for climate-related damages. All these required a review and possible alteration of existing working structures, i.e. codifying them into existing routines. These routines will in the long run constitute the organisational memory.

4) Double-loop learning and its stages are influenced by the organisational culture and structure (Kloot 1997; Lopez et al 2004; Pelling 2008). Since double-loop learning is generative in nature, it can only take place when all the aspects of an organisation are transformed and this will include the culture and structure. In the present research, the structure of the main participating organisation was hierarchical and the culture was found to be resonating between role culture and power culture where the decisions are taken by a few and the workers adhere to rules and set patterns; there was little room for transformative learning. Even throughout the implementation process, the learning was restricted to the team of facilities managers involved in the process. The structure and culture affected the learning stages as they were decisive in knowledge gathering and conservation, depending upon the role and routine of the individual in the organisation; structure and culture also affected the interaction and efforts put in for experimentation and search for new knowledge and sharing.

9.4 Objective 3 – Identifying facilities managers' perception of mitigation and adaptation

The literature review has identified that, within social constraints, an individual's perception and belief in climate change plays a part in an organisation's (and that individual's) action on climate change (Patchen 2006; Anabel et al 2006). This has been equally applicable to practising managers as individuals working in the organisational social environment. It has been argued that risk perception and its association with behavioural intentions about climate change which are not definitive (people are uncertain about the cause of climate change) is a candidate predictor of action for climate change. It has also been suggested that risk perception, knowledge and environment belief are interrelated and that increased knowledge will initiate action even in the presence of a weak signal in relation to climate change (O'Connor et al 1999).

In addition, the Ipsos MORI 2010 survey for DEFRA identified that among many business personnel the understanding of the terms 'mitigation' and 'adaptation' differ from that developed by the scientific community in the literature. On this basis, a facilities manager's perception of climate change and its interrelationship with that manager's ecological belief and approach to mitigation and adaptation were explored. Their understanding of the terms 'mitigation' and 'adaptation' in a climate change context were also investigated.

Through the participatory study and questionnaire, the research indentified that FM professionals had positive ecological and environmental beliefs, suggesting their intentions and actions towards conserving or enhancing the quality of the environment would be beneficial. The belief in human-induced climate change was not found to be predominant; indeed, the participants neither believed nor disbelieved that climate change was human-induced. The perception persisted that climate change was offering an opportunity to the business rather than representing a risk.

9.4.1 Interrelationship between environmental awareness, anthropogenic climate change and related actions

In the logistic regression set out earlier in this thesis (see Chapter 8) environmental awareness and a belief in anthropogenic climate change were found to be interrelated, which showed that positive ecological belief was related to belief (knowledge) that climate change is human-induced. Positive ecological belief was also found to be directly related to routine actions for mitigation and to support for Government legislation on mitigation. Similarly, the belief in anthropogenic climate change was found to be negatively related to the view that climate change is used as a tool for increased taxation.

These findings support the claims found in the literature (O'Connor et al 1999) that increased knowledge about climate change can generate more support for action. This was also found to be congruent with participatory study observations, where the increased knowledge gathered during the UKCIP decision-making framework implementation had given due importance to the climate change agenda (adaptation) within the organisation. As a result, increased support for mitigation and adaptation action was available within the operational teams.

9.4.2 Relationship between risk perception, belief in anthropogenic climate change and adaptation

The questionnaire analysis revealed that the perception of climate change presenting a risk shared a positive relationship with a belief in human-induced climate change, the ecological belief and the overall adaptation approach of the organisation. These results indicate that perception of risk, along with increased knowledge, is a likely indicator of behavioural intentions (for adaptation). The observation was also made during the participatory study, where an extreme weather event that induced financial loss led to a perception that such events will increase in the future as a result of climate change and represent a risk to the properties and business functions. This perception of risk has resulted in accumulating knowledge for reducing the future impacts.

9.4.3 Understanding of 'mitigation' and 'adaptation' terminology

In addition to the findings on perception and belief of the FM professionals engaged in the research study, and in accordance with the evidences from the literature review (see Chapter 2), the questionnaire survey also revealed how the participants understood the terms 'mitigation' and 'adaptation'. It was observed that the participants' understanding of the terms were not in accordance with the definitions prevailing in the scientific community, i.e. the 'mitigation' term was understood as mitigating the future impacts of climate change events on the business and 'adaptation' as adapting to UK Government legislation for CO_2 reduction.

It was clear that this understanding prevailed widely in the SMEs and other organisations which did not have an active approach to climate change. These observations are in line with the recent Ipsos MORI (2010) survey, and with the study by Williams and Geddis (2010) which found that an inability to clearly distinguish between mitigation and adaptation concepts existed amongst survey participants showing low awareness and knowledge about climate change.

From observations outlined in aforementioned sections and their relation with literature evidence, it is to be concluded that organisational culture and structure and managerial attitude and perception are key to developing a double-loop organisational learning process necessary to drive the adaptation process and develop adaptive capacities.

9.5 Chapter summary

This chapter discusses the findings of the research study in the context of the set objectives. It firstly concludes that the present mitigation and adaptation measures in the private sector are dependent upon factors such as finance, legislation and stakeholder relationships. These could also be considered as drivers for climate change action.

The mitigation agenda has found prominence as a result of financial and legislative drivers, which are absent from the adaptation agenda. As a result, the mitigation agenda enjoys a strategic backing and resource support, while the adaptation agenda has to compete for such resources as the driver for adaptation is experience-based. Mitigation measures in the service sector are preferred if they are value for money yet not very invasive. Adaptation is present in response to an experience of extreme events, which are perceived to be increasing with future climate change. Adaptation measures include resorting to existing ‘soft’ measures such as strengthening the business continuity planning and securing insurance. Little evidence exists for indicating any long-term planned physical intervention.

The second inference is that the process of the UKICP decision-making framework implementation to address adaptation had initiated organisational learning, leading to improved understanding of existing adaptive capacity by organisations and embedded resilience by strengthening existing strategies. The adaptation options were based on present organisational adaptive capacity and were kept flexible in nature in order to incorporate any emerging information or uncertainty.

Thirdly, the research has revealed that facilities managers’ perception and belief about climate change influences the approaches taken to adaptation and mitigation. In accordance with the literature evidences, increased awareness and knowledge gathering were found to be positively related to increased action. Finally, it was observed that environmental awareness and knowledge gathering and the organisational learning process are affected by organisational culture and structure, and by individual managers’ character and attitude traits. Together, these are responsible for clarity in understanding mitigation and adaptation concepts and for taking subsequent actions.

Chapter 10: Summary of conclusions and future research directions

This chapter summarises in section 10.1 the findings of the study in the context of the original research question. In doing so it puts forward the facilitating and constraining factors in order to formulate a solution to the research questions, which is the contribution of the study to the wider research agenda. Section 10.2 presents the limitations of the study, with respect to the methodology and other related aspects. These limitations provide the grounds for future research avenues, as described in section 10.3.

10.1 Summary of findings and contribution to knowledge

This research was undertaken to fulfil the primary aim of developing a new approach for a long-term climate-adaptive facilities management strategy using existing decision-making tools and climate change projections. It required answering the question 'How can an existing risk assessment framework and climate change projections be applied to translate climate change impacts into built-asset-level risk to support maintenance and business-level decision making in a private service-sector business?' In response to this question, it is concluded that such an approach would be possible to constitute in light of dealing with the facilitating and constraining factors set out below.

The short-term planning horizon of business decision (five years), which a facilities manager has to respond to, presents a mismatch with the long-term climate change projections of 30 years. The short-term business-planning horizon does not present a long-term outlook on business progress and its requirements, and this imparts a limitation in providing a basis on which premises and other built-asset facilities can be managed. In such a scenario, adaptation is treated as an operationally reactive approach mainly created by extreme weather-induced losses initiating a bottom-up approach for which the quantified business case becomes an essential requirement.

There also exists a lack of any legislative drivers in the private sector for taking planned measures for adaptation. Because of this there remains a lack of an adaptation agenda at a strategic level and restricted financial availability for planning and taking any long-term adaptation action.

In contrast, legislation and a financial incentive through energy saving drives mitigation targets which are possible to set for short-term business horizon planning. This makes the mitigation agenda a strategic intention, taking a top-to-bottom approach, which is easier to percolate through all organisational levels. Also, much greater guidance and help is available to fulfil mitigation targets than is available for adaptation, especially in private-sector built-asset management.

Associated with these are aspects of a wider understanding of climate change projections and risk assessment guidance in the FM community and their perception and attitude towards issues of climate change. The study showed that there is a lack of understanding of climate change projections, including the related science and assessment processes, among facilities management and maintenance professionals. This is partly due to their unfamiliarity with such data and processes, attributed to the lack of its use in their day-to-day working routine.

In addition, there is an inherent uncertainty about climate change projection, a lack of availability of micro- (site-level) data, and complexity in the official guidance provided on the assessment process. These limitations have restricted a definitive business case being presented at a strategic level. As a result, the known process and data gathering and assessment was used in conjunction with wider projections and decision-making guidance for undertaking qualitative and semi-quantitative assessments, leading to adaptation options being embedded into an already existing strategic approach – i.e. strengthening business continuity planning, securing insurance and implementing relatively non-invasive flood resistance measures.

Perception and attitude towards climate change also plays a part in formulating a long-term climate change adaptive approach because even when a strong ecological belief is in existence the belief in human-induced climate change has been found not to be strong. This had led to legislatively bounded (minimum) or strategically required action for mitigation, and reactive adaptations to short-term disruptions due to extreme events. In light of experience of an extreme event, overall climate change and associated future increased occurrence of such events was perceived as a risk. Thus, instead of there being initiation of planning for long-term impacts there has been a reactive response emerging from an organisation’s routine processes. For many of the FM professionals and their respective organisations, climate change appears to be more an opportunity than a risk, further restricting the consideration of adaptation planning.

The process for formulating a climate-adaptive FM approach, through implementation of the UKCIP risk and decision-making framework, has initiated organisational learning. During the process the acquisition and interpretation of knowledge about climate change projections and its impacts on FM practices and built assets has been found to result in increasing awareness of vulnerability of built assets and related business functions. Furthermore, the resources and knowledge expertise required for assessment, interpretation and integration of adaptation options into organisational routines establish the awareness of existing adaptive capacity within the FM and strategic teams of that organisation.

Single-loop learning has been found to occur, ensuring the short-term resilience of an organisation towards future climate change impacts. The preliminary basis for generative double-loop learning for increasing adaptive capacity can be introduced.

10.2 Contribution to knowledge

This study has made a contribution to knowledge by developing a new approach for preparing the existing private-sector built-asset stock for future climate change by formulating an adaptive FM and maintenance strategy. In doing so it has presented an assessment and adaptation process observed through a participatory study. This fills a gap in existing knowledge, where the majority of suggestions for climate change adaptation and mitigation are made for newly built or future buildings.

For validation of the aforementioned approach the study had implemented the UKCIP risk and decision-making framework and climate change projection UKCIP02 with a team of FM professionals in a private-sector financial services business. This is a new approach as the implementation of the decision-making framework at the time of the study was to be found predominantly in public-sector organisations and very little evidence existed for its use by the private sector. Even though this has changed over the period of time, where the shorter process model of UKCIP's Adaptation Wizard has been used by many private-sector organisations, once again its use by maintenance and FM professionals remains limited.

The research has indicated the existence of facilitators and constraints with adaptation in the private sector, especially in the context of their FM practices and personnel. The reasoning for mitigation and adaptation actions in private service-sector businesses is presented and the aspects of understanding the mismatch between short-term business planning and long-term projection are highlighted. Although this issue has been put forward by some business surveys, this study provides evidence based on practical implementation. The research also throws light on mitigation and adaptation action and on perception and belief in relation to climate change in the wider FM community, which has not been established before.

10.3 Limitations of the work

The limitations of this work arise from use of a single participatory study, and from limited resource availability for the project to carry out extensive quantitative analysis using simulation models. More specifically:

- The participatory study has been undertaken with a large-scale corporate organisation and although validity of the results is considered reasonable from the questionnaire survey, particular attention to other medium-sized and small-scale organisations has not been covered in the study.
- The project had used the UKCIP risk and decision-making framework and UKCIP02 projections, which were not probabilistic in nature. The use of new UKCIP09 projections may be able to produce the more elaborate quantitative assessments required to take the subject further.

In addition, it should be noted that this study was undertaken during 2006 and 2007 when the main participating organisation had a substantial resource capacity to undertake the research activity and dedicate resources for wider action on climate change. It is unclear as to what impact the financial meltdown of 2008 around the world has had on the ability of organisations to plan properly for climate change actions and research activities such as those presented here.

10.4 Future research avenues

While addressing a gap in the existing literature, this study has presented aspects which enable or constrain adaptation to climate change impacts in private service-sector businesses in the context of its built asset management. These aspects, along with the limitations of the study, provide avenues for future research which are related to a wider organisational adaptation agenda. The research can in turn help translate consideration of the implications of climate change for UK business into organisational strategic approaches providing the grounds for the FM adaptive strategies for existing built assets.

Seven suggestions for further work are documented here:

1) As discussed in Chapters 2 and 9, the area of organisational learning is referred to in order to gain understanding of adaptation in private-sector businesses. This process of learning has also helped facilities managers in gaining insight into organisational adaptive capacity and addressing its built-asset resilience. It would be interesting to see whether this relationship could be further explored. Enquiry into how increasing learning capacities in cases of limited resource availability would offer a valuable insight into organisational adaptation.

2) It was observed that not all the adaptation measures are within the remit of the private-sector organisations involved and some will have to be controlled by the relevant local authorities and related public-service agencies. This calls for a framework for increased public and private sector partnerships for adaptation work. These partnerships will also help transfer knowledge acquired by local authorities with regard to risk assessment, and generate possible adaptation options gained through working towards fulfilment of NI188 under the Climate Change Act 2008. Further work to develop a suitable partnership framework would be of value.

3) The capacities of larger organisations to be resilient and to adapt to sudden or gradual climate change will differ from that of SMEs. Although the existing survey into adaptation within SMEs has revealed barriers, the research into increasing their adaptive capacity and their ability to respond to sudden and gradual climate change will help to drive the overall adaptation agenda further.

4) An understanding of the existing perception and behavioural aspects in different building profession communities, and exploration of avenues to alter these perceptions leading to increased knowledge and action for adaptation at strategic and operational level, would be valuable.

5) There have been many case studies documented on the use of the new UKCIP09 projections and related tools within different sectors to assess the risks associated with

climate change; but the wider dissemination of information and guidance, so that businesses and professionals can undertake their implementation with minimum external support, still needs to be established.

6) Policy research towards an emphasis on sector-level adaptation reporting, such as that in existence for mitigation, should be looked into. Policy research could also be oriented towards promoting long-term business strategies supported by standards and possibly legislation.

7) Since businesses in different sectors are faced with varying external pressures and threats, enquiry into how businesses in different sectors understand adaptation to climate change and assessment of their adaptive capacity for increasing resilience would be of importance.

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Appendices

APPENDICES

Appendix 1 – Interview structure

Interview agenda: To establish existing organisation approach to climate change based on three major and other additional drivers

Major drivers: finance and resources, Legislation, Market influence.

Introduction

Thank you for agreeing to the interview

Purpose of the interview

The organisation is involved in the research project where we are seeking to identify the future climate change impacts and formulate a facilities and maintenance strategy which will enable the organisation to address these impacts.

For fulfilment of the project the organisation's present approach and measures for climate change needs to be recognised on basis of which future actions can be based. For this the strategic and policy documents have been already analysed along with their drivers and constraints.

This interview is intended to ask questions which will enable the research in asserting the findings from analysis of strategic documents and any other driving or constraining elements viewed as important by you.

Procedures

Your identity and information given will be treated in strict confidence and will only be used to gain additional insight into the existing analysis of strategic documents.

The interview is not recorded; instead, notes will be taken wherever necessary. The notes and information gathered during the interview will be transcribed and sent to you at later stage for your confirmation. In case of any misinterpretation of conversation the changes will be made as per your suggestions.

Structure and timing

There are around 15 to 17 open ended questions and you are free to express and elaborate on the aspects highlighted in the questions.

The interview will take around an hour and 10 min which I will try and restrict to. Please let me know if you feel that you are running out of time or you would like to leave the interview at anytime.

I will be more than happy to clarify any questions further if you required to.

Questions

1) Since your organisation is a reputed banking organisation tell me about its expanse of operation, the functional properties it owns and type of these properties?

(No of operational properties, age, type of properties)

2) Can you tell me little about yourself as to how long have you been with the organisation and what is your primary role in the organisation?

(Working with workplace organisation or maintenance)

3) Can you throw some light on how organisations has addressed environmental aspect in past or is planning to address presently?

(environmental strategy, waste management strategy, sustainable strategy etc)

4) Are you aware of any established strategy for energy reduction or climate change?

(energy strategy, Mitigation targets)

5) What measures according to you are already in place to reduce CO_2 emission or energy efficiency?

(operation measure – efficient lighting, renewable energy procurement, staff training etc)

6) Do you feel that the measures strategy and measure taken presently are appropriate or the organisation can go further?

(more CO_2 reduction, energy reduction targets, travel based emission).

7) In your opinion the action presently taken within the organisation is primarily driven by external factors or organisation would have taken these measures in absence of external factors?

(legislation, stake holder view etc)

8) Is there any particular legislation you think is important in driving the present organisation actions for co2 reduction?

(climate change levy, Part L, EPBD)

9) Would you like to see legislation driving the CO_2 reduction within your organisation or would you prefer voluntary measure and reporting.

(CDP project, Dow jones sustainability index participation, cap on CO_2 allowance etc)

10) In your opinion are the CO_2 reduction measures presently financially viable or additional organisational resources are required to achieve the targets?

(CO_2 reduction budget, benefits through reduced energy bills)

11) In your opinion is existing external guidance and resource availability helped your organisation move further in CO_2 reduction or more sought?

(Involvement with carbon trust, energy saving trust etc)

12) In your view do the stated strategic CO_2 reduction targets and their achievement make a difference to your marketplace standing compared to your competitors or allow positive perception within the stakeholder?

(Targets from competitors, corporate image, say in environmental debate with NGO)

13) In your opinion is every department of your organisation able to take action in accordance with the strategic intend or the relationship between operational and strategic staff affect such actions?

(Involvement and opinion of operational staff in decision making, communication of the operational concern, fulfilment of strategic targets is upmost)

14) Would you agree that attitude and perception of individual is likely to affect the implementation of technical and behavioural measures for CO_2 reduction?

(Environmental concern, belief that CO_2 reduction is necessary)

15) Is there anything else that you want add to the discussions?

Close

Thank you for your valuable time and insight through the discussion. If there is anything you think you need to add or omit from our discussions please do let me know. I will be able to send you a written conversation to you in week's time, if you need to make any changes to it please do let me know and I will do so accordingly.

Thanks once again for your time.

Appendix 2 - Participatory organisation's strategic analysis

MITIGATION (2005)			
CDP RESPONSE	**ENERGY/ UTILITY 01–05**	**SUSTAINIBILITY STRATEGY (05–10)**	**WORKPLACE STRATEGY (2005)**
Energy Efficiency Accreditation	Organisation sets lower energy targets compared to its peers and no water saving targets. The energy and water targets to be incorporated in environmental reporting.	5% reduction in CO2 , 5% reduction in energy consumption and 5% reduction fossil fuel consumption from 2004 base line. 85% of properties to be provided by water meter by 2010 to 2004 baseline and 5% reduction in water consumption by 2010. Grey water recycling, rain water harvesting.	COST: 1) Energy performance certificate for 50 sites. 2) Energy targets for all properties. 3) Supplier sustainability performance. 4) Challenge reactive spends priority by 10% 5) Performance measurement systems for all suppliers. 6) Audit suppliers' planned and reactive spends against contract.
FORGE toolkit use for environmental reporting		Global reporting initiatives, report on energy management and utilities target	

From 2005 to 2009 the renewable energy procurement has increased from 20% to 92% (from 2000 to 2003 the renewable achieved was 8%; it grew to 20% by 2005).	Reduce 5% CO2 level with 2000 base level and procure 5% green energy at 2000 base year supply 20% renewable energy by 2005. (CO2 emission are sensitive to amount of renewable energy procured and is made affordable due to the levy exemption.)	In 2005, 5% of CO2 reduction is achieved through 16% of renewable energy procured (no guarantee that future contracts for renewable energy will be negotiated and energy will be cost neutral).	**DELIVERY:** 1) 100% of operational risk assessment for critical buildings. 2) Monitor supplier activity to minimise risk to the business. 3) Increase risk grantees of operational teams and customers. 4) Manage incidence and service to minimise downtime 5) Audit and assess the relationship between planned and reactive maintenance to see whether the increased management of planned maintenance management reduces the reactive maintenance. 6) Analysis of building failures specifying areas requiring priority. 7) Visit business unit with needed frequencies. 8) Attend workplace satisfaction workshop and maintain action plan and double the branches surveyed.

Collaboration with Carbon Trust The partnership has assisted the organisation gain a better insight into the impact of the Government's climate change policy on the business. In particular, the partnership is designed to deliver detailed site support and practical training sessions to reduce the impact of energy use.	Meet current and future legislation on energy saving, seen to be taking action through setting targets. Reporting the absolute CO2 emission instead of floor area based. Increase in acquisition and non-availability of historic data does not allow accurate consumption figures.	The targets mentioned in energy, CO2 and fossil fuel reduction are normalised and are adjusted for degree days, business usage charges and business purchases.	**DELIVERY (cont.):** 9) Supplier management for supplier relayed complaints, and performance improvement workshop participation with suppliers. 10) Understand supplier contracts to provide feedback to maintenance team to try and manage complaints before they happen. 11) Review business-driven requirement in terms of space, spend and service to improve ability to predict and manage variation in demand. 12) Identify list of business change initiatives and present it to senior management team for priority. 13) Develop new group work operation content for new business acquisition model. 14) Performance management systems for all contracts. Audit them and gauge performance to enhance future decision. 15) Enjoy contingency plans are in place for all major third-party services in case of supplier failure.

			16) Respond to all executive. Senior management complaints within 1 hour to confirm awareness and within 24 hours to address. 17) Manage poor performance buildings highlighted in workspace survey.
Energy efficiency investment figures cannot be separated from the expenditure on our on-going annual property (renewal and refurbishment) programmes. c) The organisation's energy efficiency costs–benefits are distorted by the procurement arrangements – unit and renewable costs.	Commit £0.75 million in 2004 for energy-saving initiative.	Specific investment in energy efficiency as stated in utilities strategy	

Local level initiative for reduction of emission.	Org scores overall ranking 2 on BRECSU energy management matrix, indicating stagnation with some orderly energy management whereby motivation and awareness are needed. Also, org has looked at short-term gain rather than taking a long-term view of the energy management. Energy awareness for FM and benchmarking of properties with in portfolio.		
	Investment in long-term target achievements: cost effectiveness is necessary.		
Adaptation was only included in later CDP responses so adaptation was not given importance in 2005.			
MITIGATION (2009)			
Business travel reduction by investing in communication technology till 2009. £25 million was invested (video conferencing, web seminars)		10% reduction in business air travel and stabilise air travel CO2 emission by 2010 to the 2005 base level.	

New BMS for key buildings and fitting existing buildings with new system kit – test and adapt viable building service technologies. BREEAM accreditation to refurbishment and new development (£55million investment from 07 to 09.)	Integration of energy management in group building and operation is found to be low, so decision support, relationship management and awareness are necessary. The system and operation and FM&L personnel were first time involved in procurement in 2001–05.	BREEAM rating for new construction and life cycle costing for new construction and refurbishment.	
Web-based carbon tool for the employee.			
Sustainability in supply chain scoping study with suppliers for assessing their environmental impact and how to reduce it.	The maintenance services are contracted so energy performance standards has to be included in contracts	Supplier environmental performance.	
ISO14001 for key buildings.		Implement ISO 14001, EMAS and environmental reporting guidelines.	
92% of energy was from renewable.			
Paperless banking (switching to e-statements) and reducing the product and customer emissions and providing investment to the renewable energy production and efficiency schemes.		25% reduction in paper consumption by 2010; also reduction in recycle waste and landfill waste.	

ADAPTATION			
Screening risk to properties			
Simulation model for flooding for London based properties			
Climate change taken into account for new properties (especially data centres).			
Disaster recovery and business continuity planning specially for IT based data centres and all major sites			
Risk due to disruption to the major suppliers inability to deliver (addressed through business continuity review program of key suppliers)		Supplier capability assessment	
Remote working			

The energy/utilities strategy were set in accordance to the legislative requirement and reputation factors the issues are highlighted in these strategy reports on the targets set by utility strategy and also reports on CSR. The sustainability strategy also talks about targets set and achieved through group work operations strategy. The overall targets achieved and future plan are mentioned in the CDP.

From 2000 to 2005 the company struggled with a new initiative for energy efficiency and CO_2 management and only rested to procuring renewable energy as an answer to the climate change levy. Very few initiatives were projected for overall long-term CO2 emission and energy efficiency. The company furthered its commitment for renewable energy for exemption from climate change levy and achieved BREEAM, ISO14001 and EMAS for many of its key properties. It also worked on its adaptation initiatives and supplier sustainability and travel emissions.

Appendix 3 – List of priory codes from organisational strategic analysis

Primary	**Secondary**	**Tertury**	**SR No**
Measure	Technical	Monitoring and warning system	1
		Backup systems	2
		Energy meters	3
		Energy efficient lights	4
	Behavioural/operational	Remote working	5
		Home based working	6
		staff awareness	7
		Training portal	8
	Business based	Insurance	9
		Permanent site closure	10
		Renewable energy contracts	11
Organisational approach to climate change	Proactive	CO2 strategy	12
		Energy efficiency	13
		Conference participation	14
		Policy influence	15
		Partnerships	16
		CDP	17
	Reactive	Legislation fulfilment	18
		Minimum spent	19
	Profit seeking	Mitigation drive support	20
		Mitigation products	21
External factors	Legislation	CRC	22
		Part L	23
	CSR	Customer demand	24
		Reputation	25
	Market drive	Rival targets	26
		Market standing	27
finance	Governmentt support	Tax rebate	28
		Carbon trust	29
	Internal finance availability	Refurbishment or maintenance budget	30
		Additional funding	31
existing stock and ownership	New buildings	Acquired assets	32
		New construction	33
	Historic assets	Listed buildings	34
	Leased or owned premises	Rented	35
		Own by acquired business	36

Organisational strategic priority	Cost	Maintenance spent	37
		Profit and efficiency	38
		Contract negotiation	39
	Customer and service delivery	Customer service	40
		Efficient operation	41
Internal Process	Management integration	Senior management	42
		Responsibility	43
		Strategic approach	44
		Decision making process	45
		Bottom up approach	46
	Short term benefit approach	Prioritisation	47
		Audit	48
FM perception on climate change	Belief in climate change	Climate models	49
		Uncertainty	50
		Long term change	51
	Organisational role	Organisation capacity	52
		Government support	53
	Risk / Opportunity	Flooding, seal level rise, heavy rain	54
		Energy bills	55
		New products	56
Knowledge skills and resources	Time		57
	Money		58
	Lack of staff knowledge and expertise	Information, guidance, training, external consultation	59
Facilitating or driving factors	Research	UKCIP framework, Royal Haskonig Consulatant.	60
	Strategic support	Top level agreement	61
		Adaptation agenda, risk management	62
	Guidance availability	UKCIP, CIRIA, IPCC, local authority, Defra, environmental agency	63
	Staff values and commitment		

Appendix 4: UKCIP framework's Key questions for implementation method decision

Key questions	Answer for formulating the context
1. How much will it cost? - Applying certain types of tools, particularly those involving the extensive collection of data or the development of quantitative assessment models, can be costly. - Inexpensive off-the-shelf computer packages are available that can facilitate model development. - However, expert assistance will still be required, particularly in understanding the underlying assumptions of the tools.	For the purpose of the study, the aspect of cost was not fixed. The intention was to use the in-house capacity in terms of resources to arrive at appropriate decisions. Although modelling the problem may require the use of simulation and computer modelling, the relevant expertise would be called upon if found appropriate by higher strategic decision makers in terms of an investment made in such processes.
2. How long will it take? - The timescale involved in applying tools can often be longer than decision makers (and sometimes their analysts) realise. Timescales for decision making may be much shorter. No matter how useful a tool might potentially be, it is of little use if it cannot meet the decision deadline. - The decision maker will need to judge the risk involved in taking a decision in the absence of the benefits that a more detailed analysis might bring.	The time for the entire process and decision to be implemented was a maximum of one year. This was due to the nature of the FM strategy structure, as the update for FM strategy was a done on a quarterly timescale. If more detailed analysis is required and the resources are not available, a temporary measure to protect the organisation's properties will be recommended till the time necessary for further analysis has been found.
3. To what extent will the analysis improve the decision? - There is little point in undertaking a sophisticated analysis, at a potentially high cost, if it adds little to the quality of the decision making. Nevertheless, decision makers may feel less vulnerable if their decision is based on the best available data and science.	In the absence of a decision made on the basis of detailed analysis, the recommendation made on the basis of the best data available would be implemented and monitored.
4. Can appropriate data and information be obtained? - If not, the preceding criteria will need to be considered.	The data on built-asset maintenance and flooding maps from the Environment Agency would act as a starting point for the analysis. The requirement of the data would be assessed as the framework proceeded.
5. Who will undertake the analysis? - If the use of particular tools requires specialist input, can that input be provided in-house or will it be necessary to seek (and, perhaps, pay for) external advice?	The initial analysis will be undertaken by the facilities managers from the organisation's FM department, and especially the FM of the properties assessed to be at risk would be involved closely in decision making. In a case of expertise required, the financial resources for external consultants will be requested from the organisation's decision makers. In a case of resources not granted, recommend-dations would be made on the best available data and expertise.

Appendix 5 – Evidence from the UKCIP02 scientific report for future increased precipitation

1) Winters will become wetter and summers may become drier everywhere. The relative changes will be largest for the High Emissions scenario and in the South and East of the United Kingdom, where summer precipitation may decrease by 50% or more by the 2080s and winter precipitation may increase by up to 30%. Summer soil moisture by the 2080s may be reduced by 40% or more over large parts of England for the High Emissions scenario. (Source: taken from the UKCIP02 Briefing Report)

2) Heavy winter precipitation (rain and snow) will become more frequent. By the 2080s, winter daily precipitation intensities that are experienced once every two years on average may become between 5% (Low Emissions) and 20% (High Emissions) heavier. (Source: taken from the UKCIP02 Briefing Report)

Evidences fromUKCIP02 scientific report

1) Winter precipitation has increased and intense rainstorms within total winter precipitation have increased across the whole country during the last 40 years. The 'heavy rain' (rain lasting at least five days) has also increased (high confidence).

2) Increase in winter precipitation by 30% by 2080 for the midrange in the High Emissions scenario. In Scotland it will be higher till 2020 due to natural variability (high confidence). Eastern and southern parts of Britain will have the largest percentage changes.

3) For summer, the rainfall decreases for the Low Emissions scenario by up to 20% and increases by up to 40% for the High Emissions scenario.

4) For winter, the precipitation ranges from -5% to 35%. For properties in northern England and Scotland, it is 20–30% more and for southern and eastern England it is 10–20% (information gathered from fig 37 in UKCIP scientific report).

5) Winter precipitation variability is greater, especially in eastern England: wet winters like 1994/95 will occur on average once a decade (66% wetter than average). (Medium confidence)

6) In southwest Scotland and southwest Wales for the midrange in the High Emissions scenario, by 2080 a doubling of intense precipitation frequency will be observed. Frequency and intensity of wet days in winter will increase in eastern England by 0.5–1.5 days per season by 2080 in the midrange for the High Emissions scenario for all parts of England.

7) There will be an increase in magnitude of 2-year events in southeast England and southeast Scotland of 20% for the midrange of the High Emissions scenario.

8) The probabilities of heaviest daily events in winter increases for all sub-regions. The probabilities of increase are larger for southern regions.

9) For the midrange of the High Emissions scenario, for central and southern England the probabilities by 2080 that a given winter day will have precipitation in excess of 20mm will be about 2%, rather than the present likelihood of 1%. (High confidence).

Appendix 6: Flood management questionnaire for council

Title: Flood management questionnaire

Name of your council:…………………………………………………………………………………………..
Date:……………………………………………………………………………………………………..……

This questionnaire is intended to gather information on flood management aspects of your council. Your responses will help a PhD research study into climate adaptive facilities management, which is being undertaken at the University of Greenwich. All data produced through this questionnaire will be treated in confidence and will only be used for the purpose of the study. No data will be published in an attributable form. Thank you for your time and participation.

Q1) Has there been a flooding event in your area in last 2 to 3 years due to

	No. of flood occurred at level 1 severity	No. of flood occurred at level 2 severity	No. of flood occurred at level 3 severity	No. of flood occurred at level 4 severity
a) River flooding.				
b) Heavy rainfall overflowing the drainage and sewer system.				
c) Storm surge.				
d) Flash floods.				
e) Flooding due to rising ground water.				
f) Flooding due to blow out to dams or over spilling of reservoirs.				
g) Other (please specify below).				

Level 1 severity- flood warning issued basic caution to be taken in case of flooding.
Level 2 severity- closer of roads, disruption of electricity.
Level 3 severity- business and houses flooded at ground floor level.
Level 4 severity- extreme flooding resulting in evacuation.

Q2) If there was a flood in your area what measures were taken? (Please fill in the table below and tick the appropriate).

A) Before flooding

	Flood warning issued (Please tick)	Means of warning issued a) Phone, b) Web, c) Letters, d) Local media (tick below)	How much warning was give prior to flooding (in hours)	Closer of roads and public buildings (Please tick)	Disruption of electricity supply (Please tick)	Relocating people from to be flooded area (Please tick)
a) River flooding.	Yes No	a b c d		Yes No	Yes No	Yes No
b) Heavy rainfall overflowing the drainage and sewer system.	Yes No	a b c d		Yes No	Yes No	Yes No

c) Storm surge.	Yes No	a b c d		Yes No	Yes No	Yes No
d) Flash floods.	Yes No	a b c d		Yes No	Yes No	Yes No
e) Flooding due to rising ground water.	Yes No	a b c d		Yes No	Yes No	Yes No
f) Flooding due to blow out to dams or over spilling of reservoirs.	Yes No	a b c d		Yes No	Yes No	Yes No
g) Other.	Yes No	a b c d		Yes No	Yes No	Yes No

Q2ai) In case of relocation were any precautions taken to safe guard the property in likely affected areas? (Please tick the appropriate).

Yes……………………………………………………………No……………………………………………………

Q2aii) If yes please mention them below (for e.g. reinforcing new defenses, provision of sandbags).
……
……

B) During flooding

	Security measures taken to avoid damage to private properties (please tick appropriate)	Do you have an emergency plan in place? (Please tick)	If yes how effective do you think it was a) very ineffective, b) ineffective, c) effective, d) very effective (tick below)
a) River flooding.	Yes No	Yes No	a b c d
b) Heavy rainfall overflowing the drainage and sewer system.	Yes No	Yes No	a b c d
c) Storm surge.	Yes No	Yes No	a b c d
d) Flash floods.	Yes No	Yes No	a b c d
e) Flooding due to rising ground water.	Yes No	Yes No	a b c d
f) Flooding due to blow out to dams or over spilling of reservoirs.	Yes No	Yes No	a b c d
g) Other.	Yes No	Yes No	a b c d

Q2bi) Please provide a web link to the emergency plan if possible:
……

C) After flooding

	Was any recovery plan activated? (Please tick)	Cleaning & reopening roads (time taken in hour)	Re-connecting electricity supply (time taken in hr)	Drainage cleaning (time taken in hr)	Commencing regular water supply (time taken in hr)
a) River flooding.	Yes No	Avg time taken:	Avg time taken:	Avg time taken:	Avg time taken:
b) Heavy rainfall overflowing the drainage and sewer system.	Yes No	Avg time taken:	Avg time taken:	Avg time taken:	Avg time taken:
c) Storm surge.	Yes No	Avg time taken:	Avg time taken:	Avg time taken:	Avg time taken:

d) Flash floods.	Yes No	Avg time taken:	Avg time taken:	Avg time taken:	Avg time taken:
e) Flooding due to rising ground water.	Yes No	Avg time taken:	Avg time taken:	Avg time taken:	Avg time taken:
f) Flooding due to blow out to dams or over spilling of reservoirs.	Yes No	Avg time taken:	Avg time taken:	Avg time taken:	Avg time taken:
g) Other.	Yes No	Avg time taken:	Avg time taken:	Avg time taken:	Avg time taken:

Q2ci) Please provide a web link to the emergency plan if possible:
………
………

Q2cii) Please mention the total recovery time taken for local businesses to re-open and any help provided by the council to ensure the continuity of business affected.
………
………

Q3) Have you (as a council /department) been advised of any change to the flood risk in your area over next (please tick appropriate).

5yr .Yes…… No … *10 yr.* Yes…… No … *15 yr* . Yes…… No … *20 yr* . Yes… No …
25yr. Yes… No…

If you did not answer the above question please go to question 8.

Q4) If you tick any of the above please mention the level of risk (please tick appropriate). and mention possible cause of flooding?

Same as before		Possible cause of flooding.
Moderately increased		
A lot more		

Q5) Who has given advised to (the council /department) about future change to flood risk?
………
………
………

Q6) Are there any plan in place to act in case of the future flood risk? (Please tick appropriate).

Yes…………………………………………………No……………………………………………

Q7) If yes please mention them below.
………
………
………
………
………
………
………
………
………
………
………

………
………
………
………
………
………

Q8) Thank you for your participation. If you would like a copy of the summary report resulting from this questionnaire then please provide the following.

Name:……

Address:………………………………………………………………………………………………………
………
………

Phone:………………………………….. e-mail:…………………………………………………………..

Q9) Please tick the boxes if you are willing to participate in a short follow up interview.

Yes ……………………………………………………… No…………………………………………………

Disclaimer: The information provided in this questionnaire would be treated in absolute confidence. The information would be used strictly for the study purpose and will not be used publicly.

Please reply back to

Api Desai,
School of architecture and construction,
University of Greenwich,
Mansion site,
Avery hill campus,
Bexely road,
Eltham SE9 2PQ.
Ph: 02083318035. e-mail: da231@gre.ac.uk

Appendix 7: Example of costing methodology

Below is an example of future risk to two properties due to heavy rain induced as a result of climate changes during 2011–2100 Note that the time series are divided in to three groups: 2011-2040 (2020), 2041- 2070 (2050) and 2071–2100 (2080). The years in brackets are the shorthand forms for what each time series is known by (so 2011–40 is the '2020' series).

Risk due to climate changes 2011–2100

1) Present-day estimated cost of repair due to heavy rain and local flood event:
Property 1=£100,000
Property 2=£128,000

2) Present-day probability of such heavy rain and flood occurring is 1 in 100 years, which is 0.01 probability.

3) Future cost of such damage with increase in market prices for 2011–2100 but with no climate change (i.e. present probability of such events =0.01) is calculated as 95.1% for the 2020 time series and 110% for the 2050 and 2080 time series. (ref: UKCIP SES world market scenario)

Therefore £100,000*95.1= £195,100
£128,000*95.1= £249,728 +
£444,828
£444828 / 2 = £222,414 (average cost)

Total annual flooding cost of both properties with future market increase but no climate change = Property damage cost × present climate probability =

£222,414 * 0.01 = £222,4.14 (£2,300 rounding up to nearest £100)

Similarly the cost rise due to market changes in 2050 at 110% increase is calculated to be £2,500

Therefore (rounding to the nearest £100 again) we have:

Total annual flooding cost for Prop1and Prop2 with future increase in market price built in but with no climate change factor considered.		
2011–40 (2020)	2041–71 (2050)	2071–2100 (2080)
£2,300	£2,500	£2,500

3) Total estimated annual cost under future socio-economic scenario (price increase due to market growth only) for 2011 to 2100 in total is based on 2000 and 2004 prices (a) = approximately £220,000 [(£2300×30yr) + (£2500×30yr) + (£2500×30yr)]

4) Probability of years experiencing heavy rain as per climate change scenario (b) (UKCIP02 High Emissions scenario):

2011–40 (2020)	2041–71 (2050)	2071–2100(2080)
1.07%	3.59%	8.30%

5) Cost of repair in future per annum due to climate change = a × b:

2011–40 (2020)	2041–71 (2050)	2071–2100 (2080)
£2,300 × 1.07=£2,509	£2,500 × 3.59 =£8,997	£2,500 × 8.30 = £20,764

6) Net cost induced due to climate change =
cost of repair due to climate change – cost under future socio-economic growth:

2011–40 (2020)	2041–71 (2050)	2071–2100 (2080)
£2,509 – £2,300 = £209	£8,997 – £2,500=£6,497	20,764 – £2,500=£18,264

Total cost of flood damage due to future climate change for the period 2011–2100 will be approximately £750,000: [(£209×30yr) + (£6,497×30yr) + (£18,264×30yr)] = £749,110.

7) For calculating the total present value of damage cost caused due to climate-change-induced heavy rain and flooding with no adaptive measure except straight repair cost, the discounted costs are calculated (for detail explanation of discounted value see note-1 below).

Discounted climate-change-induced costs =
Undiscounted climate change induced annual cost × appropriate discount factor. So we have:

£209 * 0.400 (discount factor of 3.5% discount rate)
£6,497 * 0.190 (discount factor of 3.0% discount rate)
£18,264 * 0.082 (discount factor of 2.5% discount rate)

2011–40 (2020)	2041–70 (2050)	2071–2100 (2080)
£86	£1,264	£1,510

8) Thus the present discounted cost/ present value of climate-change-induced heavy rain over the 90-year period is approximately £86,000 [(£86×30yr) + (£1,264×30yr) +(£1,510×30yr)] = £85,800.

9) Present discounted cost/ present value of heavy rain and flooding without climate change (only on the basis of a future change in price due to market changed socio-economic scenario is

Discounted cost /value of heavy rain and flooding without climate change at present =
Cost without climate change (increase only due to future market increase) * appropriate discount factor:

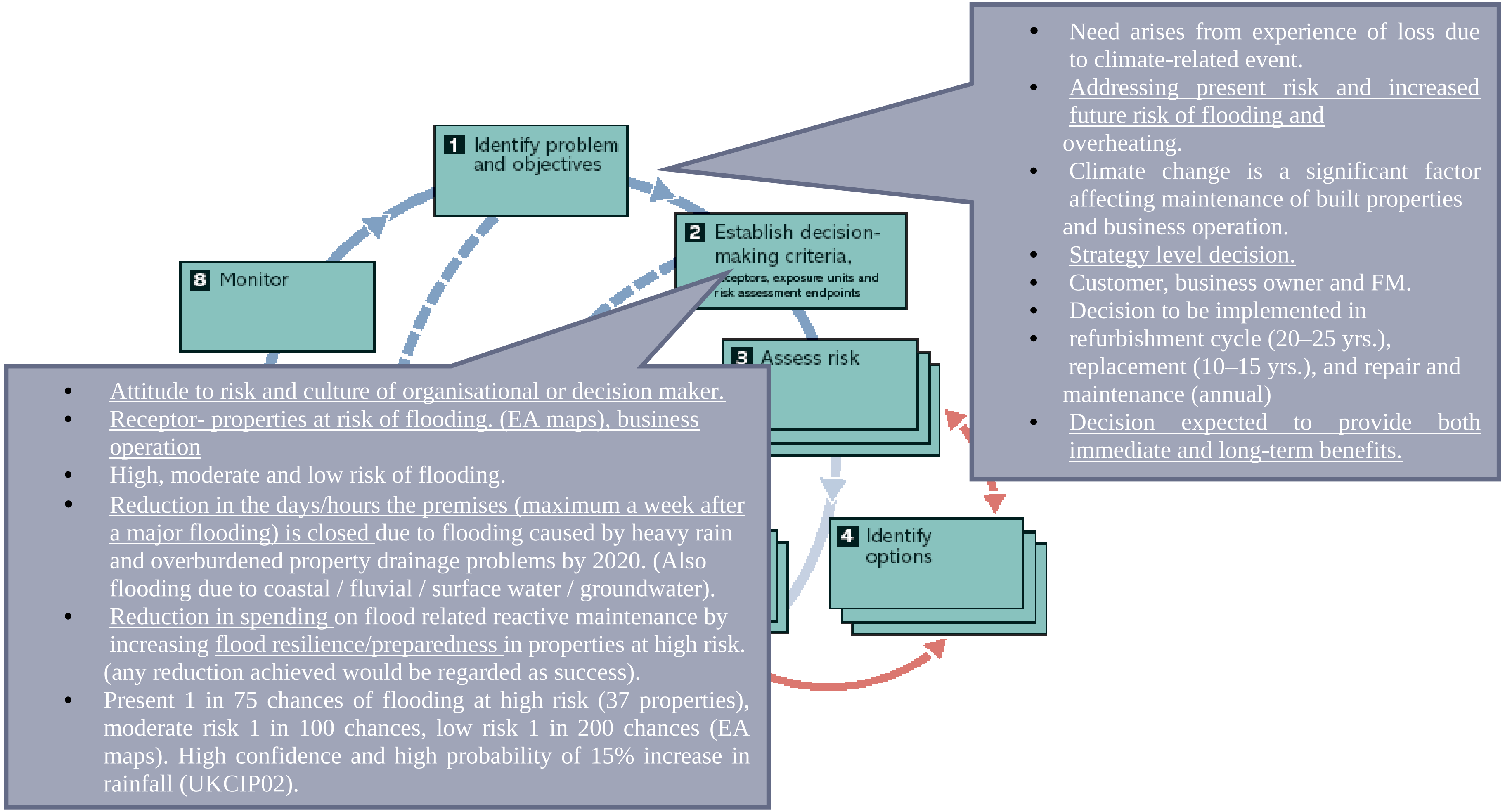
Discounted cost /value of heavy rain and flooding without climate change at present		
2011–40 (2020)	2041–70 (2050)	2071–2100 (2080)
£2,300 × 0.41 = £943	£2,500 × 0.192 = £480	£2,500 × 0.082 = £205

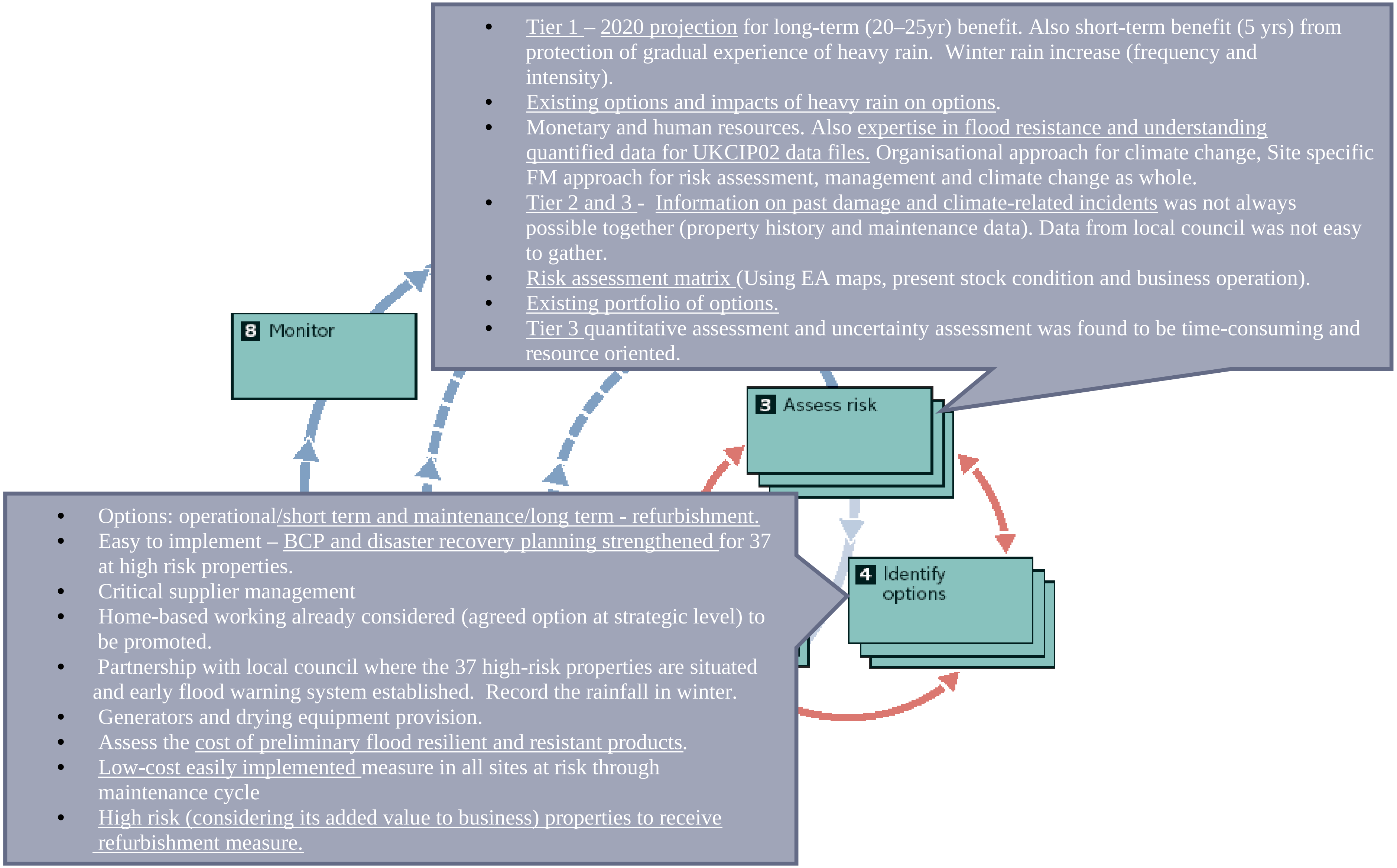
So the total discounted cost /value of heavy rain and flooding over 90 years without climate change at present is around £50,000 [(943*30yr) + (£480*30yr) + (£205*30yr)] = £48,840, which needs to be discounted from the original average cost of £220,000, yielding £170,000.

Therefore the present value of flood damage including climate change would rest between £86,000 and £170,000.

Note 1- Discounting is the conventional approach used by economists to weight and add environmental costs and benefits that occur at different points in time. Discounting arises because individuals are observed to attach less weight to a benefit or cost in the future than they do to a benefit or cost now. Referring to the UK Treasury's *Green Book*, a discount rate of 3.5% should be applied to impacts occurring in 0–30 years from present, 3.0% for 31–75 years and 2.5% for 76–125 years. The discount rate determines the weight assigned to the climate-induced cost in each future year.

Appendix 8: Diagrammatic presentation of UKCIP framework implementation process




• Tier 1 – 2020 projection for long-term (20–25yr) benefit. Also short-term benefit (5 yrs) from protection of gradual experience of heavy rain. Winter rain increase (frequency and intensity).
• Existing options and impacts of heavy rain on options.
• Monetary and human resources. Also expertise in flood resistance and understanding quantified data for UKCIP02 data files. Organisational approach for climate change, Site specific FM approach for risk assessment, management and climate change as whole.
• Tier 2 and 3 - Information on past damage and climate-related incidents was not always possible together (property history and maintenance data). Data from local council was not easy to gather.
• Risk assessment matrix (Using EA maps, present stock condition and business operation).
• Existing portfolio of options.
• Tier 3 quantitative assessment and uncertainty assessment was found to be time-consuming and resource oriented.
8 Monitor
3 Assess risk
4 Identify options
• Options: operational/short term and maintenance/long term - refurbishment.
• Easy to implement – BCP and disaster recovery planning strengthened for 37 at high risk properties.
• Critical supplier management
• Home-based working already considered (agreed option at strategic level) to be promoted.
• Partnership with local council where the 37 high-risk properties are situated and early flood warning system established. Record the rainfall in winter.
• Generators and drying equipment provision.
• Assess the cost of preliminary flood resilient and resistant products.
• Low-cost easily implemented measure in all sites at risk through maintenance cycle
• High risk (considering its added value to business) properties to receive refurbishment measure.

Appendix 9 Questionnaire survey

FM Opinion and Action for Climate Change

Thanks for considering and participating in the survey. The entire survey will not take more than 10 - 15 min of your time. The questions are divided into 5 sections. Section 1 is includes general information questions, section 2 consists of organisation information, section 3 and 4 comprises of questions relating to measures taken for climate change and section 5 is composed of questions regarding your opinion about climate change. Please provide your contact details at the end of the survey where by we can send you the summary of the findings. If you do not wish to answer any question please proceed to the next question and send in the fully or partially completed survey by clicking on the submit button at the end of the survey.

Section 1: General Information

NOTE: If you are not working within Facilities, Maintenance , Building Operation, Estate management or for a FM consultancy can you please pass this questionnaire to the relevant person with in your organisation who is involved with any of the above.

Q1 Which of the following best describes your organisation ? (you may tick more than one box)

- ☐ Commercial
- ☐ Industrial
- ☐ Retail
- ☐ Utilities
- ☐ Recreational
- ☐ Educational
- ☐ Health Sector
- ☐ Government
- ☐ FM consultants
- ☐ FM Contractors

Q2 Is your organisation an: (please tick the relevant)

- ○ SME
- ○ UK based corporate company
- ○ Multinational

Other (please specify) __________

Approximately how many employees work for your organisation? _____

NOTE: If you are an 'FM Consultant or Contractor / facilities services supplier please answer the remainder of the questionnaire from your client's organisation perspective (e.g. Answer 'Q6 ' considering awareness and knowledge of your client's organisation/s)

Q3 Which of the following best describes your current role?

- ○ Executive FM manager (responsible for strategy)
- ○ Senior FM manager (responsible for a building or group of buildings)
- ○ FM manager (responsible for specific FM service/s e.g.maintenance)
- ○ Operational FM (team member)

Other (please specify) __________

Q4 To which of the following are you directly accountable?

- ○ The board
- ○ CEO
- ○ FM Director
- ○ FM Manager

Other (please specify) [ ]

Q5 Are you a member of any of the following organisations?

☐ BIFM ☐ IFMA ☐ EuroFM ☐ CIBSE ☐ RICS ☐ CIOB

Other (please specify) [ ]

Section 2: Organisational response

Q6 How would you rate the level of awareness / knowledge of climate change with in your organisation? (1 = very aware / knowledgeable, 5 = un-aware / no knowledge)

	1	2	3	4	5	Don't Know
a) Awareness of climate change amongst senior management	○	○	○	○	○	○
b) Knowledge of the impacts of climate change amongst senior management	○	○	○	○	○	○
c) Awareness of climate change amongst junior management	○	○	○	○	○	○
d) Knowledge of the impacts of climate change amongst junior management	○	○	○	○	○	○
e) Your personal awareness of climate change	○	○	○	○	○	○
f) Your personal knowledge of the impacts of climate change	○	○	○	○	○	○

Q7 Please indicate your level of agreement with following statements? (1 = strongly agree, 3 = neither agree nor disagree, 5 = strongly disagree)

	1	2	3	4	5	Don't Know
a) Climate change represents a significant risk to our primary business function	○	○	○	○	○	○
b) Climate change will affect the way FM supports an organisation's primary business function	○	○	○	○	○	○
c) Climate change represents an opportunity to develop new products or services	○	○	○	○	○	○

Q8 Which of the following best describes your organisation's approach to climate change? (please tick as many as relevant) My organisation has...

☐ Identified a senior / junior manager to take responsibility for our approach to climate change

☐ Instigated training programs for senior/junior managers on the subject of climate change

☐ Taken practical steps to assess the impacts of climate change at the strategic level

☐ Commissioned external consultants to advise us on the impact of climate change

☐ Not addressed the issue of climate change

☐ Taken practical steps to assess the impacts of climate change at an operational level

☐ we are aware of impact of climate change but is yet to take any practical steps

Q9 **If your organisation has taken any specific actions to address climate change, please give a brief description below**

Section 3: Adapting to Climate Change Impacts

Adaptation : Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates, harm or exploits beneficial opportunities. e.g.- construction of flood defence in future flooding areas

Q10 **Have any climate related events affected you or your working environment in last 2 to 3 years ?** *(for e.g.: (1) Sudden or extreme rainfall causing flooding and disturbing transport, fresh water, electricity supply and access to your business or damage your premises. (2) Coastal erosion or rise in sea level causing damage to property near the coast (3) Sudden storm or hurricanes have damaged your premises and affected your organisations functions. (4) Extreme hot weather resulting in uncomfortable working environment, causing staff absenteeism and increasing energy demand.*

○ Yes ○ No ○ Don't know

If 'YES' please outline any measures you took / are considering to address the impact

Q11 **Has the event resulted in you considering any future impacts on your organisational functions which may occur due to climate change ?**

○ Yes ○ No ○ Don't know

Q12 **Do you consider the impacts of climate change as part of your routine disaster recovery planning / (risk assessment)?**

○ Yes ○ No ○ Don't Know

Q13 **If the following were to occur what level of impact do you think they will have on the buildings that you currently occupy / manage?**

	Significant	Major	Moderate	Minor	None	Don't Know
a) More winter rain	○	○	○	○	○	○
b) More frequent storms	○	○	○	○	○	○
c) Decreased snowfall	○	○	○	○	○	○
d) Increased winter temperature	○	○	○	○	○	○

f) More frequent and severe flooding	○	○	○	○	○	○
g) Sea level rise	○	○	○	○	○	○
h) More extremely hot summers	○	○	○	○	○	○
i) More summer droughts	○	○	○	○	○	○
j) Changes in seasonality (e.g.an early spring)	○	○	○	○	○	○

If you have scored any of the above as 'significant' or 'major' what impacts do you anticipate

Q14 For those factors in 'Q13' whose impacts you rated as significant or major, which of the following generally describes your organisation's approach to addressing them?

- ○ We have measures in place to deal with the anticipated impacts
- ○ We know we need to consider the impacts but lack the technical expertise to evaluate the risks
- ○ We have prioritised the risks and are addressing the most important impacts
- ○ We are currently considering how to deal with the anticipated impacts
- ○ We know we need to consider the impacts but it is not currently a high priority in our organisation
- ○ We have not yet started to consider the impacts

Section 4: Mitigation Measures for Climate Change

Mitigation : An intervention to reduce climate change including: strategies to reduce greenhouse gas sources and emissions (e.g. generating power from carbon neutral sources, carbon off-setting)and enhancing greenhouse gas sinks.

Q15 Do you consider mitigation measures for climate change as a routine part of your FM strategy?

☐ Yes ☐ No ☐ Don't Know

Q16 Which of the following are covered by your FM strategy?

	Fully covered	Partially covered	Not covered	Don't Know
a) Building stock assessed for energy efficiency savings	○	○	○	○
b) Building stock assessed for retrofitting of micro generation technologies e.g. PV, micro-CHP etc)	○	○	○	○
c) Energy efficiency credentials of your supply chain	○	○	○	○
d) Training for staff to control and reduce energy consumption	○	○	○	○
e) Procuring low energy building consumables (e.g.energy efficient lighting)	○	○	○	○

☐ Energy Performance Certificates ☐ Enhanced capital allowances ☐ EU / UK Emission Trading Scheme

☐ Corporate Social Responsibility ☐ FTSE4good ☐ Dow Jones Sustainability index/ Dow Jones global index

Other (please specify) ____________________

Q18 Are you aware or have been involved with any of the following ? (please tick as relevant)

	Aware of	Involved with	Not aware / Don't know
a) UKCIP (UK climate change impact program adaptation wizard)	☐	☐	☐
b) UKCIP risk, uncertainty and decision making framework	☐	☐	☐
c) Energy Saving Trust	☐	☐	☐
d) Carbon Trust	☐	☐	☐
f) London Climate Change Partnership	☐	☐	☐
g) BEERAM	☐	☐	☐

Q19 Have mitigation measure taken by you / your organisation for climate change resulted in any financial benefit ?

☐ Yes ☐ No ☐ Don't Know

Section5:Opinions about Climate Change

Q20 **Please indicate your level of agreement with following statements (1 = strongly agree , 3 = neither agree nor disagree, 5 = strongly disagree)**

	1	2	3	4	5	Don't Know
a) The balance of nature is very delicate and easily upset	○	○	○	○	○	○
b) When humans interfere with nature it often has disastrous consequences	○	○	○	○	○	○
c) Mankind was created to rule over the rest of nature	○	○	○	○	○	○
d) The earth is like a spaceship with only limited room and resources	○	○	○	○	○	○
e) The so-called 'ecological crisis' facing humankind has been grately exaggerated	○	○	○	○	○	○
f) Humans have the right to modify the natural environment to suit their needs	○	○	○	○	○	○
g) Human ingenuity will ensure that we do not make the earth unliveable	○	○	○	○	○	○
h) If things continue on their present course we will soon experience a major ecological catastrophe	○	○	○	○	○	○
i) Climate change is naturally occurring phenomenon and human activity has not significantly contributed to it.	○	○	○	○	○	○
j) Private organisations will only reduce their carbon emissions in response to government legislation.	○	○	○	○	○	○
k)Industries are not convinced that government has clear policies to tackle climate change	○	○	○	○	○	○
l) Climate change is primarily a political tool for raising additional taxation	○	○	○	○	○	○

Any further comments?

Q21 In your opinion what more could your organisation do to adapt and mitigate for climate change?

a) ADAPTATION

b) MITIGATION

Q22 Would you be prepared to participate in a short follow up interview if requested?

◯ Yes ◯ No

Thank you for completing the questionnaire. If you would like to receive a short summary report of the findings, or participate in a follow up interview please provide contact details.

Name

E-mail:

Phone no:

Organisation Address:

Appendix 10 – Impacts specified by private-sector questionnaire respondents

Impacts specified from private sector

- Storms, rainfall affect the roof and drain services to the buildings. Hot weather increases the load and could cause cooling issues for data centres and common rooms.
- Problems for pubs and consumers in areas affected by flooding or in coastal areas. HVAC issue for Heating, general inadequate flood defences against flooding.
- Increased flooding of operational sites.
- Refrigeration systems and air-conditioning system failure. Electrical infrastructure overload.
- Increased energy costs due to additional heating /cooling
- Some properties will become waterlogged, with little or no access.
- Higher level of [staff] absence, risk of damage to office environment as located within reach of a river.
- Increased demand of fuels, i.e. as electricity. Roof damage? Leading to additional reactive costs.
- We have 2 major sites in the Thames flood plains.
- As our business park is built in a flood plain, more frequent flooding could leave us exposed to water ingress into our premises,
- Travel problems for staff. Increased costs - storm damage etc.
- Loss of buildings and inability of staff to get to them – real experience of this. Increase in costs.

- External flooding to site car parks and roadways.
- Building damage which could stop production. Limited availability of raw materials (timber).
- Higher risk of flooding, business loss, employees' not reaching place of work, less customers.
- Wind damage to roofing/cladding. Our computer rooms and manufacturing areas are air-conditioned using chillies. More extreme temperatures would cause our electricity bills to rise considerably. Our office areas would overheat during the summer as they are naturally ventilated. This would cause health and safety issues as well as affects employee motivation and work rate.
- Increased flooding, increased energy demand, increased energy usage, procurement of alternative energy, grey-water recycling, impact of PPM maintenance and life cycle costs of plant. Potential need to include flood and storms in BCP plan and raise building defences in certain areas. Impacts also on Insurance!
- As a chilled foods business, increases in outside temp places additional burdens on our ability to maintain internal temp within tolerances, therefore energy usage is increased.
- Internal water damage from gutters and foul pipes not being able to deal with volume of water. Internal temperatures and increased requirement for air cooling. General impact from reduced or systematic water stoppages.
- As a covered shopping centre, extremes of heat and cold ensure shopper wish to be in a covered and AHU-covered centre. We are also looking at rain harvesting so more rain is going to reduce costs. Flooding closes roads and is exaggerated in the press that is no help.
- Potential flooding and possible roof leakage, electricity supplies and communications lost, impact on staff.

- Flooding - potential for severe damage to building fabric, grounds, biodiversity and possibly staff; business disruption, high repair/maintenance costs, potential for disease; water supply issues. Sea level rise – all of the above, plus permanent displacement of business; land pressure issues, etc.
- Ground floor flooding of the premises.
- Our analysis of the EPA has shown that our property (100 years old) will suffer a flood within the next 100 years. Data points around our property indicate we will suffer a 1m coverage across the 4.5acre sites. Our power distribution boards are just short of capacity as temperatures fluctuate to meet Hot/Cold temperature fluxes even though our systems are controlled by BMS. Being a greeting card designer, manufacturer and distributor, flooding would result in product being written off either through a 'soaking' or 'damp'.
- Disposal of storm-water flooding, standing water, capacity of downpipes/guttering to handle deluges, increased demand for air-con and increase in electrical demand, more significant wear and tear on flat roofs.
- Strategic sites will be subject to flooding & business disruption.
- Difficulty getting to work – flooded roads – cost of heating / cooling / water.
- Frequent storms will cause flooding and building-fabric issues, such as roofs blowing off. Severe flooding will impact access and use of building. Sea level rise will cause flooding to low-level sites.
- Water consumption is high, and is a critical part of our process. Cost of water has already increased, and shortages could have a major impact on our ability to deliver product.
- Significant demand for cooling in our clean rooms and currently working on system capacity limits.
- Cancellation of international events and therefore shortfall in income etc.
- Damage to high-level buildings.
- Storm damage to commercial and industrial properties, resulting in down time for tenants. Hot summers mean that air-conditioning will be on more often, resulting in higher fuel costs and more CO_2 emissions.
- Some offices requiring relocation to higher ground (two within 40ft above sea level), operational efficiency of staff in poorly serviced, office may also require eventual relocation to better-serviced accommodation. Both scenarios represent significant investment.
- Wider installation of air-con systems.
- As a Data Centre using fresh-air cooling, increase in temperature at any time significantly increases our cooling costs and impacts on our ability to meet the SLAs in place regarding Data Hall temperature.
- Greater risk of flooding.
- One property is a dockland property and is in a flooding area when it rains heavily for longer periods of time.
- Strain upon existing building designs.
- We have upgraded our HVAC specs.
- Flooding of building: unable to service clients, business interruption needs to be revisited with alternative sites. Sea-level rise: coastal city for one location so possible flooding (or 'Goodbye Belfast'!!). HOT summers: currently struggle to cool building – increase investment in air-con, energy cost rise. Drought: staff unable to come to work; water for staff at work; food price increases; food shortages etc.
- Depend on sea water for cooling. Use a lot of water for production of electricity.
- Difficulty in accessing the office (we are close to River Thames).
- Water penetration and damage to building.

- Poor working conditions, installation of full air-conditioning. Window solar control.
- Uncomfortable conditions and increased expenditure to combat this.
- Not only do we need to consider the direct impact on our business but we have to consider the effect climate change has on our food producers as well. Flooding may not directly affect our properties but may affect access of our customers & staff to be able to trade in the affected area.
- Lack of air-conditioning in some facilities and increased summer fuel bills.
- Increased cooling demand, increase in power use, rise in energy costs and potential data hall shut-downs.
- Assess risk of flooding when selecting property. Additional air-conditioning and electrical demand.
- Being a water utility, operational activity will increase and occupancy times and numbers within our buildings will increase to deal with the impact on our core business.
- Damage to branches that would cause us to spend tight budgets to repair.
- Air-conditioning plant critical to operation of building with its occupants.
- Our head office is sited in Canary Wharf. Potentially, significant sea level rise or rainfall could lead to flooding, should defences such as the Thames Barrier no longer be capable of protecting us.
- There will be discomfort by the staff as it will be way too cold and the heating system may not be able to balance the situation.
- Overheating of building issue – most are naturally ventilated.
- Ours is the only street/building that would be above the flood level but [flooding] would impede staff getting to work. Plant is too old to cope with significant temperature rises.
- Our head office is close to a flood plain and is susceptible to excessive flooding events.
- More water conservation measures and need to install more cooling for staff/customer comfort.
- Our head office is close to a flood plain and is susceptible to excessive flooding events.
- Major only for increased usage in air conditioning onsite.
- Thermal comfort of office-based staff. Is the current air-conditioning systems designed to cope with extremely hot summers?
- Flooding could result in more internal leaks and staff absence due to loss of transport systems, road closures etc. Hot summers could result in loss of water supplies.
- Steep rise in demand for comfort cooling for our shopping malls, especially in the South of England.
- On our distribution warehouse in Glasgow, it will mean we don't have to heat them as much. Will flood London office.
- Buildings flooding. Major impact on ability to run business from these buildings.
- Closure of the warehousing due to flooding. Refitting warehousing with AC or filtration systems to keep staff cool during hot summers. Additional costs bringing in water for staff during droughts. Increased building maintenance both for flooding and heat.
- Situated next to a river. Cooling of building space in high temperatures.
- Drainage Problems. Air conditioning. Better trading year+.
- Inundating of the ground level of at least one major building.
- More damage to the building. Also, with more heat in the summer we may need to install air conditioning.
- Existing buildings historically sited in low-lying areas. A/C cooling of sophisticated systems and personnel reaction to inefficient existing A/C systems.
- Capacity of storm drainage to be increased by the local water authority.

- One office is located near to the coast so significant rise in sea level could impact by flooding. Hot summers could need more efforts to reduce temperatures in the workplace. Possible changes to working patterns to avoid hottest part of the day.
- We are located adjacent to a tidal area, with good sea defences.
- My client organisation runs holiday accommodation, some of which is based in areas close to sea fronts that may be impacted by increased erosion by more severe weather. Many are in exposed and isolated locations that will be impacted by extreme weather conditions. Many also do not have air conditioning and therefore more severe summers may require substantial spend to ensure the comfort of the customers.
- Due to the site of the building being by the Thames river, the threat of flooding would have a major impact on the usage of the building. Again, rising sea levels could place the building at a higher risk.
- Buildings may not be able to be used; the operation would have to be diverted elsewhere. Increased recovery costs could impact on business profit margin and reduce investment. May need to relocate to a less suitable area in the case of sea level rises.
- Air conditioning failure, excessive power consumption.
- Increased load on building cooling, leading to increased electricity consumption and elevated CO_2 emissions from electricity consumption/higher energy cost.
- Revised thinking when designing for A/C loading.
- Impact of flooding on technical buildings causing outages to customers.
- Rise in river level within London.
- Possible modifications to means of collecting and handling storm water; equipment on hand to deal with flooded basements.
- Increase in insurance costs or no insurance available for specific areas. Relocation of buildings to a safer environment.
- More flooding to be dealt with. Water use restrictions.
- We are located near the Thames and are on a floodplain. Sea rises could significantly increase our risk. Hotter summer would put more pressure on the a/c, costing the company more to run to meet the demand. With increasing utility costs, this could have a major impact, together with a shorter lifespan of plant.
- As our premises are close to the sea (no more than 500 metres), rises in sea levels could have a major impact on our business.
- F&H would both pose a potential risk to our operating sites and potential effect on production and ability to operate the business units.
- Exceptional temperatures will impact our ability to keep the working environment at optimum temperature.
- Flooding would prove very consequential as my operational works area is Portsmouth Dockyard.
- Flooding – personnel getting to site to complete duties and parking issues. Temperature increase – potential air-con failures due to increased usage.
- Flooding of basements / disruption to electricity supplies.
- Transport infrastructure; utilities infrastructure.
- Consideration of locating new developments.
- Reduction in energy usage, i.e. heating.

Impacts identified by cross-sectoral respondents

- Workplace comfort and productivity of our people whilst trying to reduce energy loads contradict each other in the office environment when dealing with extreme temperatures.
- Increased costs for strengthening of infrastructure, additional engineering solutions to cope with rises / falls in temperature, increased energy costs in terms of maintaining temperatures at either end of the scale (i.e. cooling when high, heating when low). Increased costs for water treatment plus infrastructure costs to implement recycling / reusing water.
- More flooding and more sites overheating.
- Major works to roof, general fabric of building.
- Flooding problems giving business continuity issues. Heating and cooling issues giving higher utility costs and adding to the greenhouse effect.
- A general lack of air conditioning in buildings may have to change.
- Flooding of water treatment stations. Reservoirs drying up.

Impacts identified by recreational sector respondents

- Several buildings are on flood plain and we would lose access.
- Fabric: roof maintenance, pitch recovery. Changes in growing season.

Impacts identified by FM consultants

- Increased risk of damage to plant and equipment.
- Various, mainly energy consumption and the need for better building standards.
- Complaints of overheating and costs to reduce the effect.
- An increase in the number and severity of buildings-related insurance claims. Problems for staff accessing the workplace. Increased absenteeism.
- Sea level rise would be significant but low risk.
- Air conditioning maintenance and possible enhancement.
- More floods, more storms.
- Possible leaks, storm damage to buildings, increased energy costs for HVAC, accessibility to building due to flooding, increased pest control due to flooding, increased spending.
- High cost of running air conditioning.
- Uncomfortable working environment, increased demand for air conditioning, increased use of utilities.
- In central London, flooding is a major risk and would make our offices inaccessible.
- Higher requirement on energy consumption due to increased temperatures and the like. Higher importance on disaster recovery regimes to deal with floods and other weather extremes.
- Work attendance and contact with clients.
- Problems with tenants' units being flooded, resulting in more insurance claims and higher premiums due to higher risk weightings.
- Increased utilities spend.
- Our main office is in London not far from banks of River Thames.
- Air conditioning unable to cope, staff travel issues, staff wellbeing issues.

Impacts identified by FM contractors

- Loss of building function.
- Flood damage and disruption to business operation. Displacement. Increase demand on mechanical cooling and change to staff welfare arrangements. Water rationing – affecting hygiene and some other services.
- Damage to roofs and rooftop installations from high wind. Increased use of air-conditioning and in some cases installation of air conditioning to alleviate high summer temps.
- Issues relating to chiller capacity to meet the demand for cooling in buildings.
- Flooding – need to review measures. Hot summers – look to more effective ways of keeping building cool.
- Additional rainfall increasing the potential of water ingress, damage to buildings. Also, overloading land drains causing flooding to roads and pathways. We have our own private water supply, reduced snowfall or summer droughts could reduce the water table and possibly change the water quality. Increase in summer temperatures may increase the demand for air conditioning increasing operational and maintenance costs.
- Increased summer temperature may increase demand for cooling equipment (e.g. fans, portable A/C). Increased risk of drought will result in greater demand for bottled water to be supplied for staff in the buildings (increased costs, impact on environment through transport costs etc.).
- Interruptions to ability to deliver service.
- More absenteeism. Greater risk of fires. Increased cost to control grounds. Greater cost to control heat-related problems – i.e. more frequent shift changes for employees having to wear protective clothing to ensure that they do not get dehydrated, causing greater manpower cost to cover shift changes.
- Flooding – restricted access. Damage to property.
- We have no air conditioning and the building would become uncomfortable.
- Unbearable heat within certain buildings.
- Damage to property, resulting in loss of business.
- In the Education and Healthcare market the client operation could be affected, operating costs for energy will increase as will insurance. The effect to the service provider is reflected in the full-risk PFI contracts, both financial and operational.
- We service mainly retail premises –
  1. The capability of the building's infrastructure to cope with the increased water.
  2. Impact on the buildings themselves due to more frequent storms.
  3. Impact on design and operation of refrigeration and HVAC systems.
  4. Increased energy consumption.
- Property damage and disruption to operations.
- People not turning up to work because of flooding; office closing because droughts prevents use of toilets; air conditioning not coping with summer heat, resulting in office low productivity.
- Cooling of buildings will become more difficult and expensive. Also will consume more energy.
- Unhappy customers going home with heat-related issues. Costs to the FM business in client claiming unavailability.
- Flooding to be the main issue, particularly within the coastal areas of the UK, as well as most of Scotland.
- Several older buildings would have a requirement for installation or improved air-conditioning/ventilation.

- Storms and flooding may impact on one or more premises.
- Increased water recycling & large reductions in winter energy, small increase in summer electrical energy.
- Property damage, disruption to services etc.
- Failure of air conditioning systems, unacceptable internal temperatures, shortage of water supplies.
- 1. Building is located adjacent to the River Thames. 2. Working in a hot building with an existing large cooling load. 3. Drought in the South of England may lead to water rationing; our reliance on reliable mains supply of water for building cooling etc. is total.
- Building structure could be affected as listed building.
- More buildings flooding.
- Local flooding to car parks that could affect attendance at retail units. Higher level of cooling required to keep malls cool.

Impacts identified by responses from 'unclassified' sector

- Building costs – repair damage, mitigate risks. Increase utilities [costs] – heaters /AC.
- Effect on working environment and conditions.
- We have a lot of older buildings with historical lack of investment. Storm damage is easily incurred, and more frequent storms will require us to divert capital funding from other priorities.
- Increased usage of AC, higher water usage. Significant potential damage to clients premises.
- More flooding means inability of staff to get to work.
- Additional air con, flood damage and water restrictions.
- Maintaining comfortable office temperatures.
- Less energy used to heat a single-glazed listed building. More energy used in trying to cool the same listed building without air conditioning.

Appendix 11: Correlation statistics for adaptation correlations R1 to R7

R1) Environmental inclination and belief in human-induced climate change occurrence

Correlations				
			Total NEP score (q20a to q20h)	**Belief in human induced climate change occurrence**
Spearman's rho	**Total NEP score (q20a to q20h)**	Correlation Coefficient	1.000	0.440**
		Sig. (2-tailed)	.	0.000
		N	168	168
	Belief in human induced climate change occurrence	Correlation Coefficient	0.440**	1.000
		Sig. (2-tailed)	0.000	.
		N	168	168
**. Correlation is significant at the 0.01 level (2-tailed).				

R2) Environmental awareness and perceiving climate change as a risk

Correlations				
			Climate change perceived as risk	**Total NEP score (q20a to q20h)**
Spearman's rho	**Climate change perceived as risk**	Correlation Coefficient	1.000	0.230*
		Sig. (2-tailed)	.	0.042
		N	82	79
	total NEP score (q20a to q20h)	Correlation Coefficient	0.230*	1.000
		Sig. (2-tailed)	0.042	.
		N	79	79
*. Correlation is significant at the 0.05 level (2-tailed).				

R3) Belief in human-induced climate change occurrence and perception of risk

Correlations				
			Belief in human induced climate change	**Climate change perceived as risk**
Spearman's rho	**Belief in human induced climate change**	Correlation Coefficient	1.000	0.309**
		Sig. (2-tailed)	.	0.000
		N	169	169
	Climate change perceived as Risk	Correlation Coefficient	0.309**	1.000
		Sig. (2-tailed)	0.000	.
		N	169	169
**. Correlation is significant at the 0.01 level (2-tailed).				

R4) Environmental awareness and climate change being viewed as a taxation tool

Correlations				
			Total NEP score (q20a to q20h)	**View that climate change is used as taxation tool**
Spearman's rho	**Total NEP score (q20a to q20h)**	Correlation Coefficient	1.000	–0.247**
		Sig. (2-tailed)	.	0.001
		N	166	166
	View that climate change is used as taxation tool	Correlation Coefficient	–0.247**	1.000
		Sig. (2-tailed)	0.001	.
		N	166	166
**. Correlation is significant at the 0.01 level (2-tailed).				

R5) Belief in human-induced climate change and climate change being viewed as a taxation tool

Correlations				
			Belief in human induced climate change	**View that climate change is used as taxation tool**
Spearman's rho	**Belief in human-induced climate change**	Correlation Coefficient	1.000	–0.459**
		Sig. (2-tailed)	.	0.000
		N	164	164
	View that climate change is used as taxation tool	Correlation Coefficient	–0.459**	1.000
		Sig. (2-tailed)	0.000	.
		N	164	164
**. Correlation is significant at the 0.01 level (2-tailed).				

Appendix continued overleaf

R6) Positive environmental inclination supports mitigation action in the organisation

Mitigation measure as a routine part of FM strategy vs Total NEP score (cross–tabulation)							
			Total NEP score				
			low	**moderate**	**high**	**V.high**	**Total**
Mitigation measure as routine part of FM strategy?	Yes	Count	8	20	40	14	82
		Expected Count	7.3	26.9	37.3	10.4	82.0
		% within Mitigation measure as routine part of FM strategy	9.8%	24.4%	48.8%	17.1%	100.0%
		% within Total NEP score	66.7%	45.5%	65.6%	82.4%	61.2%
		% of Total	6.0%	14.9%	29.9%	10.4%	61.2%
	No	Count	4	24	21	3	52
		Expected Count	4.7	17.1	23.7	6.6	52.0
		% within Mitigation measure as routine part of FM strategy	7.7%	46.2%	40.4%	5.8%	100.0%
		% within Total NEP score	33.3%	54.5%	34.4%	17.6%	38.8%
		% of Total	3.0%	17.9%	15.7%	2.2%	38.8%
	Total	Count	12	44	61	17	134
		Expected Count	12.0	44.0	61.0	17.0	134.0
		% within Mitigation measure as routine part of FM strategy	9.0%	32.8%	45.5%	12.7%	100.0%
		% within Total NEP score	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	9.0%	32.8%	45.5%	12.7%	100.0%

Chi-Square Tests			
	Value	**Df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	8.439[a]	3	0.038
Likelihood Ratio	8.690	3	0.034
Linear-by-Linear Association	3.956	1	0.047
N of Valid Cases	134		
a. 1 cells (12.5%) have expected count less than 5. The minimum expected count is 4.66.			

Appendix continued overleaf

R7) Correlation between climate change perception as a risk and organisational approach towards adaptation

Case processing summary						
	Cases					
	Valid		**Missing**		**Total**	
	N	**Percent**	**N**	**Percent**	**N**	**Percent**
Climate change perceived as Risk * Organisational approach to impacts.	159	100.0%	0	.0%	159	100.0%

Climate change perceived as a risk vs organisational approach to impacts (cross–tabulation)					
			Organisational approach to impacts		**Total**
			No measures in place	**Measures in place**	
Climate change perceived as a risk?	Disagree	Count	18	20	38
		Expected Count	9.8	28.2	38.0
		% within Climate change perceived as risk	47.4%	52.6%	100.0%
		% within organisational approach to impacts	43.9%	16.9%	23.9%
		% of Total	11.3%	12.6%	23.9%
	Agree	Count	23	98	121
		Expected Count	31.2	89.8	121.0
		% within Climate change perceived as risk	19.0%	81.0%	100.0%
		% within organisational approach to impacts	56.1%	83.1%	76.1%
		% of Total	14.5%	61.6%	76.1%
Total		Count	41	118	159
		Expected Count	41.0	118.0	159.0
		% within Climate change perceived as risk	25.8%	74.2%	100.0%
		% within organisational approach to impacts	100.0%	100.0%	100.0%
		% of Total	25.8%	74.2%	100.0%

Chi-Square Tests					
	Value	**df**	**Asymp. Sig. (2- sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	12.154[a]	1	0.000		
Continuity correction	10.717	1	0.001		
Likelihood ratio	11.248	1	0.001		
Fisher's Exact est				0.001	0.001
Line-by-line association	12.078	1	0.001		
No. of valid cases	159				
a. 0 cells (.0%) have expected count less than 5. Minimum expected count is 9.80. / computed for 2x2 table					

Appendix 12: Correlation chi-square statistics for adaptation

1) Experience of extreme events vs perception of risk (chi square)

Case Processing Summary						
	Cases					
	Valid		**Missing**		**Total**	
	N	**Percent**	**N**	**Percent**	**N**	**Percent**
Climate change perceived as Risk * Climate related events	120	100.0%	0	.0%	120	100.0%

Climate change perceived as a risk vs climate-related events (cross-tabulation)					
			climate related events		**Total**
			No	**yes**	
Climate change perceived as a risk?	No	Count	21	11	32
		Expected Count	16.0	16.0	32.0
		% within Climate change perceived as risk	65.6%	34.4%	100.0%
		% within climate related events	35.0%	18.3%	26.7%
		% of Total	17.5%	9.2%	26.7%
	Yes	Count	39	49	88
		Expected Count	44.0	44.0	88.0
		% within Climate change perceived as risk	44.3%	55.7%	100.0%
		% within climate related events	65.0%	81.7%	73.3%
		% of Total	32.5%	40.8%	73.3%
Total		Count	60	60	120
		Expected Count	60.0	60.0	120.0
		% within Climate change perceived as risk	50.0%	50.0%	100.0%
		% within climate related events	100.0%	100.0%	100.0%
		% of Total	50.0%	50.0%	100.0%

Continued overleaf

Chi-square tests					
	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson chi-square	4.261[a]	1	0.039		
Continuity correction[b]	3.452	1	0.063		
Likelihood ratio	4.317	1	0.038		
Fisher's Exact Test				0.062	0.031
Line-by-Line association	4.226	1	0.040		
No. of valid cases	120				
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 16.00.					
b. Computed only for a 2×2 table					

Continued overleaf

2) Extreme event vs addressing climate change adaptation (chi-square)

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Addressing climate change adaptation vs climate-related extreme events	213	100.0%	0	.0%	213	100.0%

Addressing climate change adaptation * climate related events cross tabulation					
			climate related extreme events		**Total**
			yes	**No**	
Addressing climate change adaptation	No	Count	22	38	60
		Expected Count	30.4	29.6	60.0
		% addressing climate change adaptation	36.7%	63.3%	100.0%
		% within climate related extreme events	20.4%	36.2%	28.2%
		% of Total	10.3%	17.8%	28.2%
	Yes	Count	86	67	153
		Expected Count	77.6	75.4	153.0
		% addressing climate change adaptation	56.2%	43.8%	100.0%
		% within climate related extreme events	79.6%	63.8%	71.8%
		% of Total	40.4%	31.5%	71.8%
Total		Count	108	105	213
		Expected Count	108.0	105.0	213.0
		% addressing climate change adaptation	50.7%	49.3%	100.0%
		% within climate related extreme events	100.0%	100.0%	100.0%
		% of Total	50.7%	49.3%	100.0%

Chi-Square Tests					
	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	6.585[a]	1	0.010		
Continuity Correction[b]	5.827	1	0.016		
Likelihood Ratio	6.642	1	0.010		
Fisher's Exact Test				0.014	0.008
Linear-by-Linear Association	6.554	1	0.010		
N of Valid Cases	213				
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 29.58.					
b. Computed only for a 2x2 table					

3) Involvement with institutions supporting climate mitigation/adaptation programmes

Knowledge of UK climate impact programmes					
		Frequency	**Percent**	**Valid Percent %**	**Cumulative Percent %**
Valid	**Aware**	69	14.6	16.9	16.9
	Involved	6	1.3	1.5	18.3
	Not aware/ not involved	334	70.6	81.7	100.0
	Total	409	86.5	100.0	
Missing	**System**	64	13.5		
Total		473	100.0		

UKCIP framework					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**Aware**	62	13.1	15.2	15.2
	Involved	9	1.9	2.2	17.4
	Not aware/ not involved	336	71.0	82.6	100.0
	Total	407	86.0	100.0	
Missing	**System**	66	14.0		
Total		473	100.0		

Appendix 13 – Correlation chi-square statistics for mitigation (hypothesis H5)

R1) Correlation between financial benefit from mitigation measures and CSR as an influencing driver.

Case processing summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Financial benefit of mitigation measures vs Q17 option 3	118	100.0%	0	.0%	118	100.0%

Financial benefit of mitigation measures vs CSR as influencing driver (cross–tabulation)					
			CSR as influencing driver		
			CSR not as a driver	**CSR as a driver**	**Total**
Financial benefit from mitigation measures?	**Yes**	Count	5	70	75
		Expected Count	9.5	65.5	75.0
		% within financial benefit of mitigation measures	6.7%	93.3%	100.0%
		% within CSR as influencing driver	33.3%	68.0%	63.6%
		% of Total	4.2%	59.3%	63.6%
	No	Count	10	33	43
		Expected Count	5.5	37.5	43.0
		% within financial benefit of mitigation measures	23.3%	76.7%	100.0%
		% within CSR as influencing driver	66.7%	32.0%	36.4%
		% of Total	8.5%	28.0%	36.4%
	Total	Count	15	103	118
		Expected Count	15.0	103.0	118.0
		% within financial benefit of mitigation measures	12.7%	87.3%	100.0%
		% within CSR as influencing driver	100.0%	100.0%	100.0%
		% of Total	12.7%	87.3%	100.0%

Chi-square tests					
	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson chi-square	6.778[a]	1	0.009		
Continuity correction[b]	5.366	1	0.021		
Likelihood ratio	6.504	1	0.011		
Fisher's Exact Test				0.019	0.011
Line-by-line association	6.721	1	0.010		
No. of valid cases	118				
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.47.					
b. Computed only for a 2×2 table					

R2) Correlation between the routine mitigation measures and drivers for the measures (financial and CSR).

Case processing summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Mitigation measure as routine part of FM strategy vs Financial benefit of mitigation measures	95	100.0%	0	.0%	95	100.0%

Mitigation measure as routine part of FM strategy vs Financial benefit of mitigation measures (cross-tabulation)					
			Financial benefit of mitigation measures		
			Yes	**No**	**Total**
Mitigation measure as routine part of FM strategy?	**Yes**	Count	47	15	62
		Expected Count	41.1	20.9	62.0
		% within mitigation measure as routine part of FM strategy	75.8%	24.2%	100.0%
		% within financial benefit of mitigation measures	74.6%	46.9%	65.3%
		% of Total	49.5%	15.8%	65.3%
	No	Count	16	17	33
		Expected Count	21.9	11.1	33.0
		% within mitigation measure as routine part of FM strategy	48.5%	51.5%	100.0%
		% within financial benefit of mitigation measures	25.4%	53.1%	34.7%
		% of Total	16.8%	17.9%	34.7%
	Total	Count	63	32	95
		Expected Count	63.0	32.0	95.0
		% within mitigation measure as routine part of FM strategy	66.3%	33.7%	100.0%
		% within financial benefit of mitigation measures	100.0%	100.0%	100.0%
		% of Total	66.3%	33.7%	100.0%

continued overleaf

Chi-square tests					
	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson chi-square	7.197[a]	1	0.007		
Continuity correction[b]	6.026	1	0.014		
Likelihood ratio	7.068	1	0.008		
Fisher's Exact Test				0.012	0.007
Line-by-line association	7.121	1	0.008		
No. of valid cases	95				
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.12.					
b. Computed only for a 2×2 table					

R3 overleaf

R3) Involvement with external institution and financial gain through the routine mitigation measures

Financial benefit of mitigation measures vs Involvement with external organisations (cross-tabulation)					
			Involvement with external org.		
			no	**yes**	**Total**
Financial benefit of mitigation measures	**Yes**	Count	27	49	76
		Expected Count	39.1	36.9	76.0
		% within financial benefit of mitigation measures	35.5%	64.5%	100.0%
		% within Q18d:2	31.0%	59.8%	45.0%
	No	Count	25	18	43
		Expected Count	22.1	20.9	43.0
		% within financial benefit of mitigation measures	58.1%	41.9%	100.0%
		% within Q18d:2	28.7%	22.0%	25.4%
	Don't know	Count	35	15	50
		Expected Count	25.7	24.3	50.0
		% within financial benefit of mitigation measures	70.0%	30.0%	100.0%
		% within Q18d:2	40.2%	18.3%	29.6%
	Total	Count	87	82	169
		Expected Count	87.0	82.0	169.0
		% within financial benefit of mitigation measures	51.5%	48.5%	100.0%
		% within Q18d:2	100.0%	100.0%	100.0%

Chi-square tests			
	Value	**Df**	**Asymp. Sig. (2-sided)**
Pearson chi-square	15.373[a]	2	0.000
Likelihood ratio	15.685	2	0.000
Line-by-line association	14.918	1	0.000
No. of valid cases	169		
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 20.86.			

Appendix 14 – Correlation chi-square statistics for mitigation (hypothesis H6)

R1) Identifying the impacts and considering impacts of the future climate changes in disaster recovery planning or risk assessment.

Case processing summary						
	Cases					
	Valid		Missing		Total	
	No.	Percent	No.	Percent	No.	Percent
Climate change as part of disaster recovery planning vs Anticipated impacts coded	164	100.0%	0	.0%	164	100.0%

Climate change as part of disaster recovery planning vs Anticipated impacts coded (cross–tabulation)					
			Anticipated impacts coded		Total
			None to moderate	Sig/maj	
Climate change as part of disaster recovery planning?	**No**	Count	28	30	58
		Expected Count	20.2	37.8	58.0
		% within climate change as part of disaster recovery planning	48.3%	51.7%	100.0%
		% within anticipated impacts coded	49.1%	28.0%	35.4%
		% of Total	17.1%	18.3%	35.4%
	Yes	Count	29	77	106
		Expected Count	36.8	69.2	106.0
		% within climate change as part of disaster recovery planning	27.4%	72.6%	100.0%
		% within anticipated impacts coded	50.9%	72.0%	64.6%
		% of Total	17.7%	47.0%	64.6%
Total		Count	57	107	164
		Expected Count	57.0	107.0	164.0
		% within climate change as part of disaster recovery planning	34.8%	65.2%	100.0%
		% within anticipated impacts coded	100.0%	100.0%	100.0%
		% of Total	34.8%	65.2%	100.0%

continued overleaf

Chi-square tests					
	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson chi-square	7.233[a]	1	0.007		
Continuity correction[b]	6.340	1	0.012		
Likelihood ratio	7.127	1	0.008		
Fisher's Exact Test				0.010	0.006
Line-by-line association	7.189	1	0.007		
No. of valid cases	164				
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 20.16.					
b. Computed only for a 2x2 table					

R2) Perception of risk vs identification of impact

Correlations				
			Climate change perceived as risk	**Level of impact due to more winter rain**
Spearman's rho	**Climate change perceived as Risk**	Correlation Coefficient	1.000	0.268*
		Sig. (2-tailed)	.	0.016
		N	82	81
	Level of impact due to more winter rain	Correlation Coefficient	0.268*	1.000
		Sig. (2-tailed)	0.016	.
		N	81	81
*. Correlation is significant at the 0.05 level (2-tailed).				

Correlations				
			Climate change perceived as risk	**More frequent storms**
Spearman's rho	**Climate change perceived as risk**	Correlation Coefficient	1.000	0.437**
		Sig. (2-tailed)	.	0.000
		N	82	82
	More frequent storms	Correlation Coefficient	.437**	1.000
		Sig. (2-tailed)	0.000	.
		N	82	82
**. Correlation is significant at the 0.01 level (2-tailed).				

continued overleaf

Correlations				
			Climate change perceived as risk	**Decreased snowfall**
Spearman's rho	**Climate change perceived as risk**	Correlation Coefficient	1.000	0.347**
		Sig. (2-tailed)	.	0.002
		N	82	81
	Decreased snowfall	Correlation Coefficient	.347**	1.000
		Sig. (2-tailed)	.002	.
		N	81	81
**. Correlation is significant at the 0.01 level (2-tailed).				

Correlations				
			Climate change perceived as risk	**Increased winter temperature**
Spearman's rho	**Climate change perceived as risk**	Correlation Coefficient	1.000	.251*
		Sig. (2-tailed)	.	0.024
		N	82	81
	Increased winter temperature	Correlation Coefficient	0.251*	1.000
		Sig. (2-tailed)	0.024	.
		N	81	81
*. Correlation is significant at the 0.05 level (2-tailed).				

Correlations				
			Climate change perceived as risk	**Frequent and severe flooding**
Spearman's rho	**Climate change perceived as Risk**	Correlation Coefficient	1.000	0.365**
		Sig. (2-tailed)	.	0.001
		N	82	81
	Frequent and severe flooding	Correlation Coefficient	0.365**	1.000
		Sig. (2-tailed)	0.001	.
		N	81	81
**. Correlation is significant at the 0.01 level (2-tailed).				

continued overleaf

Correlations				
			Climate change perceived as risk	**More extremely hot summers**
Spearman's rho	**Climate change perceived as risk**	Correlation Coefficient	1.000	0.293**
		Sig. (2-tailed)	.	0.008
		N	82	81
	More extremely hot summers	Correlation Coefficient	0.293**	1.000
		Sig. (2-tailed)	0.008	.
		N	81	81
**. Correlation is significant at the 0.01 level (2-tailed).				

Correlations				
			Climate change perceived as risk	**More summer droughts**
Spearman's rho	**Climate change perceived as Risk**	Correlation Coefficient	1.000	0.242*
		Sig. (2-tailed)	.	0.030
		N	82	81
	More summer droughts	Correlation Coefficient	0.242*	1.000
		Sig. (2-tailed)	0.030	.
		N	81	81
*. Correlation is significant at the 0.05 level (2-tailed).				

Correlations				
			Climate change perceived as risk	**Changes in seasonality**
Spearman's rho	**Climate change perceived as risk**	Correlation Coefficient	1.000	0.270*
		Sig. (2-tailed)	.	0.015
		N	82	81
	Changes in seasonality	Correlation Coefficient	0.270*	1.000
		Sig. (2-tailed)	.015	.
		N	81	81
*. Correlation is significant at the 0.05 level (2-tailed).				

R3) Perception of climate change as a risk vs. considering future climate impacts (chi-square)

Case Processing Summary						
	Cases					
	Valid		**Missing**		**Total**	
	No.	**Percent**	**No.**	**Percent**	**No.**	**Percent**
Climate change perceived as risk vs Event resulting in considering climate change	100	100.0%	0	.0%	100	100.0%

Climate change perceived as a risk vs Event resulting in considering climate change (cross-tabulation)					
			Event resulting in considering climate change		**Total**
			No	**Yes**	
Climate change perceived as risk?	**No**	Count	18	8	26
		Expected Count	13.0	13.0	26.0
		% within climate change perceived as risk	69.2%	30.8%	100.0%
		% within event resulting in considering climate change	36.0%	16.0%	26.0%
		% of Total	18.0%	8.0%	26.0%
	Yes	Count	32	42	74
		Expected Count	37.0	37.0	74.0
		% within climate change perceived as risk	43.2%	56.8%	100.0%
		% within event resulting in considering climate change	64.0%	84.0%	74.0%
		% of Total	32.0%	42.0%	74.0%
Total		Count	50	50	100
		Expected Count	50.0	50.0	100.0
		% within climate change perceived as risk	50.0%	50.0%	100.0%
		% within event resulting in considering climate change	100.0%	100.0%	100.0%
		% of Total	50.0%	50.0%	100.0%

continued overleaf

Chi-square tests					
	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson chi-square	5.198[a]	1	0.023		
Continuity correction[b]	4.210	1	0.040		
Likelihood ratio	5.303	1	0.021		
Fisher's Exact Test				0.039	0.020
Line-by-line association	5.146	1	0.023		
No. of valid cases	100				
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 13.00.					
b. Computed only for a 2x2 table					

R4 overleaf

R4) Experience of an extreme event vs considering future climate change impacts.

Climate related events vs Event resulting in considering climate change (cross-tabulation)					
			Event resulting in considering climate change		
			Yes	**No**	**Total**
Climate-related events experienced?	**Yes**	Count	57	16	73
		Expected Count	33.4	39.6	73.0
		% within climate related events	78.1%	21.9%	100.0%
		% within event resulting in considering climate change	87.7%	20.8%	51.4%
	No	Count	8	61	69
		Expected Count	31.6	37.4	69.0
		% within climate related events	11.6%	88.4%	100.0%
		% within event resulting in considering climate change	12.3%	79.2%	48.6%
	Total	Count	65	77	142
		Expected Count	65.0	77.0	142.0
		% within climate related events	45.8%	54.2%	100.0%
		% within event resulting in considering climate change	100.0%	100.0%	100.0%

Chi-square tests

	Value	**Df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson chi-square	63.175[a]	1	0.000		
Continuity correction[b]	60.524	1	0.000		
Likelihood ratio	69.553	1	0.000		
Fisher's Exact Test				0.000	0.000
Line-by-line association	62.730	1	0.000		
No. of valid cases	142				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 31.58./ for 2x2 table

R5) Extreme event vs identification of impact (chi square).

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	No.	Percent	No.	Percent	No.	Percent
Climate related events vs Anticipated impacts coded	175	100.0%	0	.0%	175	100.0%

Climate related events vs Anticipated impacts coded (cross-tabulation)					
			Anticipated impacts coded		Total
			none to moderate	sig/maj	
Climate related events seen?	**No**	Count	44	48	92
		Expected Count	32.6	59.4	92.0
		% within climate related events	47.8%	52.2%	100.0%
		% within anticipated impacts coded	71.0%	42.5%	52.6%
		% of Total	25.1%	27.4%	52.6%
	Yes	Count	18	65	83
		Expected Count	29.4	53.6	83.0
		% within climate related events	21.7%	78.3%	100.0%
		% within anticipated impacts coded	29.0%	57.5%	47.4%
		% of Total	10.3%	37.1%	47.4%
Total		Count	62	113	175
		Expected Count	62.0	113.0	175.0
		% within climate related events	35.4%	64.6%	100.0%
		% within anticipated impacts coded	100.0%	100.0%	100.0%
		% of Total	35.4%	64.6%	100.0%

Chi-square tests					
	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson chi-square	13.032[a]	1	0.000		
Continuity correction[b]	11.915	1	0.001		
Likelihood ratio	13.352	1	0.000		
Fisher's Exact Test				0.000	0.000
Line-by-line association	12.958	1	0.000		
No. of valid cases	175				
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 29.41.					
b. Computed only for a 2x2 table					

Appendix 15: Logistic regression statistics for adaptation equations (1), (2) and (3)

(1) Climate-related extreme events experience (CE) + Perception of climate change as a risk (PR) = Identification of future climate change impacts (IM)

Case processing summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	106	100.0
	Missing Cases	0	0.0
	Total	106	100.0
Unselected Cases		0	0.0
Total		106	100.0
a. If weight is in effect, see classification table for the total number of cases.			

Dependent variable coding

Original Value	Internal Value
none to moderate	0
sig/maj	1

Categorical variable coding

		Frequency	Parameter coding
Climate-related events	No	52	0.000
	Yes	54	1.000

Block 0: Beginning block

Iteration history[a,b,c]

Iteration		-2 Log likelihood	Coefficients
			Constant
Step 0	1	100.625	1.283
	2	99.696	1.505
	3	99.692	1.521
	4	99.692	1.521
a. Constant is included in the model.			
b. Initial -2 Log Likelihood: 99.692			
c. Estimation terminated at iteration number 4 because parameter estimates changed by less than 0.001.			

Classification table[a,b]

	Observed		Predicted	
			Anticipated impacts coded	
			none to moderate	sig/maj
Step 0	Anticipated impacts coded	none to moderate	0	19
		sig/maj	0	87
a. Constant is included in the model./ b. The cut value is 0.500				

Classification table[a,b]

	Observed		Predicted
			Percentage Correct
Step 0	Anticipated impacts coded	none to moderate	0.0
		sig/maj	100.0

a. Constant is included in the model.
b. The cut value is 0.500

Variables in the equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	1.521	0.253	36.099	1	0.000	4.579

Variables not in the equation

			Score	df	Sig.
Step 0	Variables	Climate related extreme events	15.132	1	0.000
		Climate change perceived as a risk	14.294	1	0.000
	Overall Statistics		26.390	2	0.000

Block 1: Method = Enter

Iteration history[a,b,c,d]

Iteration		-2 Log likelihood	Coefficients		
			Constant	Extreme events	Risk perception
Step 1	1	80.346	-0.950	1.044	0.477
	2	71.700	-1.886	1.854	0.783
	3	70.215	-2.375	2.405	0.940
	4	70.128	-2.493	2.594	0.978
	5	70.127	-2.500	2.610	0.980
	6	70.127	-2.500	2.611	0.980

a. Method: Enter
b. Constant is included in the model.
c. Initial -2 Log Likelihood: 99.692
d. Estimation terminated at iteration number 6 because parameter estimates changed by less than 0.001.

Omnibus tests of model coefficients

		Chi-square	df	Sig.
Step 1	Step	29.565	2	0.000
	Block	29.565	2	0.000
	Model	29.565	2	0.000

Model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	70.127[a]	0.243	0.399

a. Estimation terminated at iteration number 6 because parameter estimates changed by less than 0.001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	2.115	5	0.833

Contingency table for Hosmer and Lemeshow Test

		Anticipated impacts coded = none to moderate		Anticipated impacts coded = sig/maj		Total
		Observed	Expected	Observed	Expected	
Step 1	1	7	6.882	3	3.118	10
	2	5	5.871	10	9.129	15
	3	5	3.751	14	15.249	19
	4	2	1.419	13	13.581	15
	5	0	0.632	14	13.368	14
	6	0	0.366	21	20.634	21
	7	0	0.079	12	11.921	12

Classification table[a]

	Observed		Predicted	
			Anticipated impacts coded	
			none to moderate	sig/maj
Step 1	Anticipated impacts coded	none to moderate	7	12
		sig/maj	3	84

a. The cut value is 0.500

Classification table[a]

	Observed		Predicted
			Percentage Correct
Step 1	Anticipated impacts coded	none to moderate	36.8
		sig/maj	96.6

a. The cut value is 0.500

Variables in the equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Climate related extreme events	2.611	0.821	10.102	1	0.001	13.606
	Climate change perceived as a risk	0.980	0.308	10.148	1	0.001	2.665
	Constant	-2.500	1.034	5.845	1	0.016	0.082

a. Variable(s) entered on step 1: Extreme events, Risk perception

Correlation matrix

		Constant	Climate related extreme events	Climate change perceived as a risk
Step 1	Constant	1.000	-0.282	-0.947
	Climate related extreme events	-0.282	1.000	0.162
	Climate change perceived as a risk	-0.947	0.162	1.000

Casewise list[b]

Case	Selected Status[a]	Observed anticipated impacts coded	Predicted	Predicted Group	Temporary Variable Resid	Temporary Variable ZResid
1	S	n**	0.888	s	-0.888	-2.817
78	S	n**	0.888	s	-0.888	-2.817

a. S = Selected, U = Unselected cases, and ** = Misclassified cases.

b. Cases with studentized residuals greater than 2.000 are listed.

(2) Extreme events resulting in examining climate change impacts (CIM) + Identification of future climate change impacts (IM) = Including climate change impacts in disaster recovery or future risk assessment (DR)

Case processing summary			
Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	106	100.0
	Missing Cases	0	.0
	Total	106	100.0
Unselected Cases		0	.0
Total		106	100.0
a. If weight is in effect, see classification table for the total number of cases.			

Dependent variable coding	
Original Value	Internal Value
No	0
Yes	1

Categorical variable coding			
		Frequency	Parameter coding
Anticipated impacts coded	none to moderate	19	0.000
	sig/maj	87	1.000
Event resulting in considering climate change	No	55	0.000
	Yes	51	1.000

Block 0: Beginning block

Iteration History[a,b,c]			
Iteration		-2 Log likelihood	Coefficients
			Constant
Step 0	1	131.508	0.755
	2	131.473	0.794
	3	131.473	0.794
a. Constant is included in the model.			
b. Initial -2 Log Likelihood: 131.473			
c. Estimation terminated at iteration number 3 because parameter estimates changed by less than 0.001.			

Classification Table[a,b]				
	Observed		Predicted	
			Climate change as part of disaster recovery planning	
			No	Yes
Step 0	Climate change as part of disaster recovery planning	No	0	33
		Yes	0	73
	Overall Percentage			
a. Constant is included in the model. b. The cut value is 0.500				

Classification table[a,b]			
	Observed		Predicted
Step 0	Climate change as part of disaster recovery planning	No	0.0
		Yes	100.0
	Overall Percentage		68.9

a. Constant is included in the model.

b. The cut value is 0.500

Variables in the equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	0.794	0.210	14.326	1	0.000	2.212

Variables not in the equation

			Score	df	Sig.
Step 0	Variables	Event resulting in considering future impacts	8.337	1	0.004
		Identification of future impacts	2.846	1	0.092
	Overall Statistics		9.066	2	0.011

Block 1: Method = Enter

Iteration history[a,b,c,d]

Iteration		-2 Log likelihood	Coefficients		
			Constant	Event resulting in considering future impacts	Identification of future impacts
Step 1	1	122.693	-0.043	0.942	0.420
	2	122.205	-0.064	1.163	0.454
	3	122.203	-0.065	1.180	0.455
	4	122.203	-0.065	1.181	0.455

a. Method: Enter

b. Constant is included in the model.

c. Initial -2 Log Likelihood: 131.473

d. Estimation terminated at iteration number 4 because parameter estimates changed by less than 0.001.

Omnibus tests of model coefficients

		Chi-square	df	Sig.
Step 1	Step	9.270	2	0.010
	Block	9.270	2	0.010
	Model	9.270	2	0.010

Model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	122.203[a]	0.084	0.118

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than 0.001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	1.259	2	0.533

Contingency table for Hosmer and Lemeshow Test

		Climate change as part of disaster recovery planning = N		Climate change as part of disaster recovery planning = Y		Total
		Observed	Expected	Observed	Expected	
Step 1	1	9	8.260	7	7.740	16
	2	15	15.740	24	23.260	39
	3	0	0.740	3	2.260	3
	4	9	8.260	39	39.740	48

Classification table[a]

	Observed		Predicted	
			Climate change as part of disaster recovery planning	
			No	Yes
Step 1	Climate change as part of disaster recovery planning	No	9	24
		Yes	7	66

a. The cut value is 0.500

Classification table[a]

	Observed		Predicted
			Percentage Correct
Step 1	Climate change as part of disaster recovery planning	No	27.3
		Yes	90.4
	Overall Percentage		70.8

a. The cut value is 0.500

Variables in the equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Event resulting in considering future impacts	1.181	0.474	6.196	1	0.013	3.256
	Identification of future impacts	0.455	0.549	0.688	1	0.407	1.577
	Constant	-0.065	0.472	0.019	1	0.891	0.937

a. Variable(s) entered on step 1: Considering future climate changes, impacts identification.

Correlation matrix

		Constant	Event resulting in considering future impacts	Identification of future impacts
Step 1	Constant	1.000	-0.123	-0.815
	Event resulting in considering future impacts	-0.123	1.000	-0.258
	Identification of future impacts	-0.815	-0.258	1.000

Casewise List[a]

a. The casewise plot is not produced because no outliers were found.

(3) Perception of climate change as risk (PR) + Identification of future impacts (IM) = Events resulting in considering future climate change impacts (CIM)

Case processing summary			
Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	106	100.0
	Missing Cases	0	.0
	Total	106	100.0
Unselected Cases		0	.0
Total		106	100.0
a. If weight is in effect, see classification table for the total number of cases.			

Dependent variable coding	
Original Value	Internal Value
No	0
Yes	1

Categorical variable coding			
		Frequency	Parameter coding
Anticipated impacts coded	none to moderate	19	0.000
	sig/maj	87	1.000

Block 0: Beginning Block

Iteration history[a,b,c]			
Iteration		-2 Log likelihood	Coefficients
			Constant
Step 0	1	146.796	-0.075
	2	146.796	-0.076
a. Constant is included in the model.			
b. Initial -2 Log Likelihood: 146.796			
c. Estimation terminated at iteration number 2 because parameter estimates changed by less than 0.001.			

Classification table[a,b]				
	Observed		Predicted	
			Event resulting in considering climate change	
			No	Yes
Step 0	Event resulting in considering climate change	No	55	0
		Yes	51	0
	Overall Percentage			
a. Constant is included in the model.				
b. The cut value is 0.500				

Classification table[a,b]

	Observed		Predicted
			Percentage Correct
Step 0	Event resulting in considering climate change	No	100.0
		Yes	0.0

a. Constant is included in the model.

b. The cut value is 0.500

Variables in the equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	-.076	.194	.151	1	0.698	0.927

Variables not in the equation

			Score	df	Sig.
Step 0	Variables	Identification of future impacts	9.689	1	0.002
		Perception of climate change as risk	2.830	1	0.093
	Overall Statistics		10.025	2	0.007

Block 1: Method = Enter

Iteration history[a,b,c,d]

Iteration		-2 Log likelihood	Coefficients		
			Constant	impacts(1)	Risk Perception
Step 1	1	136.145	-1.682	1.459	0.115
	2	135.886	-1.991	1.733	0.124
	3	135.884	-2.019	1.760	0.125
	4	135.884	-2.020	1.761	0.125

a. Method: Enter

b. Constant is included in the model.

c. Initial -2 Log Likelihood: 146.796

d. Estimation terminated at iteration number 4 because parameter estimates changed by less than 0.001.

Omnibus tests of model coefficients

		Chi-square	df	Sig.
Step 1	Step	10.912	2	0.004
	Block	10.912	2	0.004
	Model	10.912	2	0.004

Model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	135.884[a]	0.098	0.130

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than 0.001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	0.959	4	0.916

Contingency table for Hosmer and Lemeshow Test

		Event resulting in considering climate change = N		Event resulting in considering climate change = Y		Total
		Observed	Expected	Observed	Expected	
Step 1	1	7	7.705	2	1.295	9
	2	9	8.295	1	1.705	10
	3	4	4.113	4	3.887	8
	4	12	11.310	12	12.690	24
	5	15	14.971	19	19.029	34
	6	8	8.607	13	12.393	21

Classification table[a]

	Observed	Predicted		
		Event resulting in considering climate change		
		No		Yes
Step 1	Event resulting in considering climate change	No	20	35
		Yes	7	44

a. The cut value is 0.500

Classification table[a]

	Observed		Predicted
			Percentage Correct
Step 1	Event resulting in considering climate change	No	36.4
		Yes	86.3

a. The cut value is 0.500

Variables in the equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Identification of impacts	1.761	0.693	6.457	1	0.011	5.817
	Perception of climate change as risk	0.125	0.207	0.364	1	0.546	1.133
	Constant	-2.020	0.856	5.561	1	0.018	0.133

a. Variable(s) entered on step 1: impacts, Risk perception.

Correlation matrix

		Constant	impacts(1)	Risk perception
Step 1	Constant	1.000	-0.480	-0.678
	Identification of impacts	-0.480	1.000	-0.277
	Perception of climate change as risk	-0.678	-0.277	1.000

Casewise list[b]

Case	Selected Status[a]	Observed	Predicted	Predicted Group	Temporary Variable	
		Event resulting in considering climate change			Resid	ZResid
78	S	1**	0.146	0	0.854	2.423
81	S	1**	0.146	0	0.854	2.423

a. S = Selected, U = Unselected cases, and ** = Misclassified cases.

b. Cases with studentized residuals greater than 2.000 are listed.

Appendix 16: Collinearity statistics for adaptation/mitigation logistic regression

(1) Climate-related extreme-events experience (CE) + Perception of climate change as a risk (PR) = Identification of future climate change impacts (IM)

Variables entered/removed				
Model		Variables Entered	Variables Removed	Method
	1	Climate change perceived as risk, climate related events.	0	Enter
a. All requested variables entered.				
b. Dependent variable: anticipated impacts coded				

Coefficients[a]			
Model		Collinearity Statistics	
		Tolerance	VIF
1	Climate related events	0.987	1.013
	Climate change perceived as risk	.987	1.013
a. Dependent Variable: anticipated impacts coded0			

Collinearity diagnostics[a]								
Model		Dimension		Eigenvalue	Condition index	Variance proportions		
						(Constant)	Climate-related events	Climate change perceived as risk
	1		1	2.593	1.000	0.01	0.05	0.01
			2	0.366	2.661	0.03	0.95	0.03
			3	0.041	7.947	0.96	0.00	0.96
a. Dependent variable: anticipated impacts coded								

(2) Extreme events resulting in considering climate change impacts (CIM) + Identification of future climate change impacts (IM) = Including climate change impacts into disaster recovery or future risk assessment (DR)

Variables entered/removed[b]				
Model		Variables Entered	Variables Removed	Method
	1	Event resulting in considering climate change, Anticipated impacts coded[a]	0	Enter
a. All requested variables entered.				
b. Dependent variable: climate change as part of disaster recovery planning				

Coefficients[a]			
Model		Collinearity statistics	
		Tolerance	VIF
1	Anticipated impacts coded	0.909	1.101
	Event resulting in considering climate change	0.909	1.101
a. Dependent variable: climate change as part of disaster recovery planning			

Collinearity diagnostics[a]							
Model	Dimension		Eigenvalue	Condition Index	Variance Proportions		
					(Constant)	anticipated impacts coded	event resulting in considering climate change
1	dimension 1	1	2.551	1.000	0.02	0.02	0.05
		2	0.356	2.676	0.09	0.05	0.93
		3	0.093	5.237	0.89	0.92	0.01
a. Dependent variable: climate change as part of disaster recovery planning							

(3) Perception of climate change as risk (PR) + identification of future impacts (IM) = extreme events resulting considering future climate change impacts (CIM)

Variables entered/removed[b]				
Model		Variables Entered	Variables Removed	Method
0	1	Anticipated impacts coded, Climate change perceived as risk[a]	0	Enter
a. All requested variables entered.				
b. Dependent variable: event resulting in considering climate change				

Coefficients[a]			
Model		Collinearity Statistics	
		Tolerance	VIF
1	Climate change perceived as Risk	0.865	1.156
	Anticipated impacts coded	0.865	1.156
a. Dependent Variable: event resulting in considering climate change			

Collinearity diagnostics[a]							
Model	Dimension		Eigenvalue	Condition Index	Variance proportions		
					(Constant)	Climate change perceived as risk	Anticipated impacts coded
1		1	2.852	1.000	0.01	0.01	0.02
		2	0.107	5.159	0.14	0.08	0.97
		3	0.041	8.355	0.85	0.91	0.01
a. Dependent variable: event resulting in considering climate change							

(4) Legislative drivers (REG) + strategic drivers (CSR) + organisation size (ORG) = Addressing mitigation at operational level

Variables entered/removed[b]			
Model	Variables Entered	Variables Removed	Method
1	Organisational size, Strategic drivers, Legislative drivers	.	Enter
a. All requested variables entered.			
b. Dependent variable: see questionnaire Q8a section 6			

Coefficients[a]			
Model		Collinearity Statistics	
		Tolerance	VIF
1	Strategic Drivers	0.991	1.009
	Legislative Drivers	0.975	1.026
	organisational size	0.969	1.032
a. Dependent variable: see questionnaire Q8a section 6			

Collinearity diagnostics[a]							
Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	Strat.	Leg.	Organisational size
1	1	3.444	1.000	0.00	0.01	0.03	0.01
	2	0.428	2.837	0.01	0.02	0.96	0.01
	3	0.093	6.071	0.02	0.77	0.02	0.29
	4	0.034	9.998	0.96	0.19	0.00	0.70
a. Dependent variable: Operational measures							

(5) Financial benefit from mitigation measures (FMIT) + Addressing climate change at strategic level (ST) = Mitigation measure forms part of routine FM strategy (MITROU)

Variables entered/removed[b]

Model	Variables Entered	Variables Removed	Method
1	Addressing Climate change at strategic level, financial benefit of mitigation measures[a]	.	Enter

a. All requested variables entered.

b. Dependent variable: Mitigation measures as a routine part of FM strategy

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	Financial benefit of mitigation measures	0.991	1.009
	Addressing Climate change at strategic level	0.991	1.009

a. Dependent variable: Mitigation measures as a routine part of FM strategy

Collinearity diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions		
				(Constant)	Financial benefit of mitigation measures	Addressing Climate change at strategic level
1	1	2.498	1.000	0.04	0.05	0.05
	2	0.340	2.712	0.00	0.46	0.63
	3	0.163	3.918	0.96	0.50	0.32

a. Dependent variable: Mitigation measures as a routine part of FM strategy

Appendix 17: Logistic regression statistics for mitigation equations (4) and (5)

(4) Legislative drivers (REG) + Strategic drivers (CSR) + Organization size (ORG) = Addressing mitigation at operational level

Case processing summary			
Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	98	99.0
	Missing Cases	1	1.0
	Total	99	100.0
Unselected Cases		0	.0
Total		99	100.0
a. If weight is in effect, see classification table for the total number of cases.			

Dependent variable coding

Original Value	Internal Value
No	0
Yes	1

Categorical Variable coding

		Frequency	Parameter coding	
			(1)	(2)
Organisational size	SME	12	0.000	0.000
	UK Corporate	33	1.000	0.000
	Multinational	53	0.000	1.000
Legislative	No	51	0.000	
	Yes	47	1.000	
Strategic	No	12	0.000	
	Yes	86	1.000	

Block 0: Beginning Block

Iteration History[a,b,c]			
Iteration		-2 Log likelihood	Coefficients
			Constant
Step 0	1	134.384	0.245
	2	134.384	0.246
	3	134.384	0.246
a. Constant is included in the model.			
b. Initial -2 Log Likelihood: 134.384			
c. Estimation terminated at iteration number 3 because parameter estimates changed by less than 0.001.			

Classification table[a,b]					
	Observed		Predicted		
			Strategic		% Correct
			No	Yes	
Step 0	Operational mitigation measures	No	0	43	0.0
		Yes	0	55	100.0

a. Constant is included in the model.

b. The cut value is 0.500

Variables in the equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	0.246	0.204	1.462	1	0.227	1.279

Variables not in the equation

			Score	df	Sig.
Step 0	Variables	Strategic	5.379	1	0.020
		Legislative	9.646	1	0.002
		SME	1.388	2	0.499
		UK corporate	0.406	1	0.524
		Multinational	1.257	1	0.262
	Overall Statistics		18.004	4	0.001

Block 1: Method = Enter

Iteration history[a,b,c,d]							
Iteration		-2 Log likelihood	Coefficients				
			Const.	Strategic	Legisl.	SME	UK corp.
Step 1	1	115.386	-0.759	1.457	1.334	-0.787	-1.199
	2	114.920	-0.833	1.755	1.545	-1.019	-1.508
	3	114.918	-0.834	1.777	1.559	-1.041	-1.534
	4	114.918	-0.834	1.777	1.559	-1.041	-1.534

a. Method: Enter

b. Constant is included in the model.

c. Initial -2 Log Likelihood: 134.384

d. Estimation terminated at iteration number 4 because parameter estimates changed by less than 0.001.

Omnibus tests of model coefficients

		Chi-square	df	Sig.
Step 1	Step	19.466	4	0.001
	Block	19.466	4	0.001
	Model	19.466	4	0.001

Model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	114.918[a]	0.180	0.241

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	1.371	4	0.849

Contingency table for Hosmer and Lemeshow Test

		Operational = No		Operational = Yes		Total
		Observed	Expected	Observed	Expected	
Step 1	1	8	8.422	3	2.578	11
	2	14	14.800	9	8.200	23
	3	10	8.443	6	7.557	16
	4	2	1.681	4	4.319	6
	5	7	6.604	17	17.396	24
	6	2	3.050	16	14.950	18

Classification table[a]

	Observed		Predicted		
			Strategic measure		Percentage Correct
			No	Yes	
Step 1	Operational measures	No	32	11	74.4
		Yes	18	37	67.3

a. The cut value is 0.500

Variables in the equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Strategic	1.777	0.752	5.594	1	0.018	5.914
	Legislative	1.559	0.474	10.795	1	0.001	4.754
	SME			3.912	2	0.141	
	UK corporate	-1.041	0.834	1.555	1	0.212	0.353
	Multinational	-1.534	0.805	3.627	1	0.057	0.216
	Constant	-0.834	0.875	0.909	1	0.340	0.434

a. Variable(s) entered on step 1: strategic, legislative, org size

Correlation matrix

		Const.	Strategic	Legislative	UK corp.	Multinational
Step 1	Constant	1.000	-0.601	-0.125	-0.519	-0.539
	Strategic	-0.601	1.000	0.117	-0.231	-0.231
	Legislative	-0.125	0.117	1.000	-0.188	-0.264
	UK corporate	-0.519	-0.231	-0.188	1.000	0.817
	Multinational	-0.539	-0.231	-0.264	0.817	1.000

Casewise list[b]

Case	Selected Status[a]	Observed	Predicted	Predicted Group	Temporary Variable	
		Operational			Resid	ZResid
57	S	1**	0.133	0	0.867	2.553

a. S = Selected, U = Unselected cases, and ** = Misclassified cases.

b. Cases with studentized residuals greater than 2.000 are listed.

(5) Financial benefit from mitigation measures (FMIT) + Addressing climate change at strategic level (ST) = Mitigation measures form part of routine FM strategy (MITROU)

Case processing summary			
Unweighted cases[a]		N	Percent
Selected Cases	Included in Analysis	99	100.0
	Missing Cases	0	0.0
	Total	99	100.0
Unselected cases		0	0.0
Total		99	100.0
a. If weight is in effect, see classification table for the total number of cases.			

Dependent variable coding	
Original Value	Internal Value
No	0
Yes	1

Categorical variable coding			
		Frequency	Parameter coding
Operational measure	No	430	0.000
	Yes	56	1.000
Strategic measure	No	39	0.000
	Yes	60	1.000
Financial benefit of mitigation measures	No	35	0.000
	yes	64	1.000

Block 0: Beginning block

Iteration history[a,b,c]			
Iteration		-2 Log likelihood	Coefficients
			Constant
Step 0	1	127.381	0.626
	2	127.371	0.648
	3	127.371	0.648
a. Constant is included in the model.			
b. Initial -2 Log Likelihood: 127.371			
c. Estimation terminated at iteration number 3 because parameter estimates changed by less than .001.			

Classification table[a,b]					
	Observed		Predicted		
			Mitigation measure as routine part of FM strategy		
			No	yes	% Correct
Step 0	Mitigation measure as routine part of FM strategy	No	0	34	0.0
		Yes	0	65	100.0
	Overall Percentage				65.7
a. Constant is included in the model.					
b. The cut value is .500					

Variables in the equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	0.648	0.212	9.374	1	0.002	1.912

Variables not in the equation					
			Score	df	Sig.
Step 0	Variables	Financial benefit	7.009	1	0.008
		Strategic measure	8.188	1	0.004
		Operational measure	9.537	1	0.002
	Overall Statistics		18.056	3	0.000

Block 1: Method = Enter

Iteration history[a,b,c,d]						
Iteration		-2 Log likelihood	Coefficients			
			Const.	Financial benefit	Strategic	Legislative
Step 1	1	109.370	-0.872	0.880	0.749	0.840
	2	108.593	-1.050	1.066	0.900	1.017
	3	108.587	-1.067	1.083	0.914	1.034
	4	108.587	-1.067	1.083	0.914	1.034

a. Method: Enter
b. Constant is included in the model.
c. Initial -2 Log Likelihood: 127.371
d. Estimation terminated at iteration number 4 because parameter estimates changed by less than 0.001.

Omnibus tests of model coefficients

		Chi-square	df	Sig.
Step 1	Step	18.783	3	0.000
	Block	18.783	3	0.000
	Model	18.783	3	0.000

Model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	108.587[a]	0.173	0.239

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	2.395	5	0.792

Contingency table for Hosmer and Lemeshow Test

		Mitigation measure as routine part of FM strategy = No		Mitigation measure as routine part of FM strategy = Yes		Total
		Observed	Expected	Observed	Expected	
Step 1	1	9	8.929	3	3.071	12
	2	6	5.262	4	4.738	10
	3	5	6.447	8	6.553	13
	4	3	3.809	10	9.191	13
	5	4	3.395	8	8.605	12
	6	4	2.591	6	7.409	10
	7	3	3.567	26	25.433	29

Classification table[a]

	Observed		Predicted		
			Mitigation measure as routine part of FM strategy		
			No	Yes	% correct
Step 1	Mitigation measure as routine part of FM strategy	No	15	19	44.1
		Yes	7	58	89.2

a. The cut value is 0.500

Variables in the equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Financial benefit	1.083	0.477	5.160	1	0.023	2.955
	Strategic	0.914	0.486	3.537	1	0.060	2.494
	Operational	1.034	0.485	4.551	1	0.033	2.813
	Constant	-1.067	0.482	4.894	1	0.027	0.344

a. Variable(s) entered on step 1: routine mitigation measure, Strategic measure, Operational measure

Correlation matrix

		Constant	Financial	Strategic	Operational
Step 1	Constant	1.000	-0.609	-0.440	-0.355
	Financial benefit	-0.609	1.000	0.037	0.014
	Strategic measure	-0.440	0.037	1.000	-0.251
	Operational measure	-0.355	0.014	-0.251	1.000

Casewise list[b]

Case	Selected Status[a]	Observed	Predicted	Predicted Group	Temporary Variable	
		Mitigation measure as routine part of FM strategy			Resid	ZResid
36	S	0**	0.877	1	-0.877	-2.670
51	S	0**	0.877	1	-0.877	-2.670
75	S	0**	0	1	-0.877	-2.670

a. S = Selected, U = Unselected cases, and ** = Misclassified cases.

b. Cases with studentized residuals greater than 2.000 are listed.

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1) Jones, K and Desai, A (2006), “ An aasset mmanagement sstrategy to aaccommodate changing cclimate.”, CIB W70 tTrondheim iinternational symposium, Proceedings on changing user ddemands on bbuildings: Needs for llifecycle pplanning and management”, June 2006,

2) Desai, A and Jones, K. (2010)., “Examination of existing facilities management approaches to climate change and future directions ", Proceedings of CIB W70 – FM in the experience economy, Sao Paulo, Brazil, September 2010.

3) Desai, A and Jones, K(2012), “Facilities managers’ attitude towards adaptation and mitigation”, Proceedings of CIB W70- Delivering value to community, Cape town,January 2012.

4) Desai, A., Ali, f. and Jones, K. (2012), “Barriers to build asset adaptation in private service sector.”, Chameleon Research Workshop on Barriers to Adaptation to Climate Change, Berlin, 18th – 21st September 2012.