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Article

Strategies to Redress the Resilience of Residential Buildings Following Climatic Impacts: Perspectives from the UK Construction Industry

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Abstract: Housing environments are designed to provide comfort and protection but climate change has compromised the resilience of residential buildings. This study examines the impacts of climate change on UK residential buildings, identifying key vulnerabilities and adaptation strategies. A qualitative approach was used, involving ten semi-structured interviews with experts. A thematic analysis of the interview transcripts using NVivo (V.14) software revealed connections between climate change drivers and building factors such as location, age, orientation, typology, and material integrity. Adverse effects on buildings and occupants include structural degradation, increased energy demands, and indoor discomfort. This study underscores the importance of multi-stakeholder collaboration among housing owners, community members, construction professionals, and policymakers to enhance the resilience of buildings. Construction professionals are seen as key players in the implementation of mitigation and adaptation measures. This study emphasises the need for proactive adaptation measures, informed policy interventions, and improved construction practices to safeguard housing against climate change. It contributes to understanding the effects of climate change on UK residential buildings and offers strategic insights for improving their resilience.



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Keywords: construction professionals; climate change; remedial measures; residential buildings; resilience and adaptation

1. Introduction

According to the World Meteorological Organisation (2023), recent heatwaves have triggered wildfires in the United States, Canada, and the Mediterranean [1]. Furthermore, in a matter of hours, several months' worth of rain poured down in various parts of the world, including Europe and the United Kingdom, leading to catastrophic flooding. Madge (2021) stated that over 60 years ago, a comparison of two 30-year periods (1961–1990 and 1991–2020) indicated that the average temperature in the UK rose by 0.8 °C, rainfall increased by 7.3%, and sunshine increased by 5.6%. [2]. The Climate Change Committee's (2024) assessments highlight the rising disparity between the level of hazards and the existing adaptation activities since their 2017 assessment. Proactively adapting to the effects of climate change on UK residential structures is more cost-effective than delaying action since prevention is always better than treatment [3]. Climate change has threatened the sustainability of UK residential structures; thus, these buildings must be adapted to accommodate climatic variations. Considering how buildings in the UK remain functional in the present and future in the face of climate change's impact is essential. According to

the UK Green Building Council (2024), the UK construction industry is becoming more aware of the urgent need to respond to the advancing climate crisis, which includes rising temperatures, changing rainfall patterns, droughts, and increased flooding, all of which pose significant threats to the built environment and those who live in it [4]. The built housing environment deserves decreasing occupant vulnerability to climate risk, safeguarding against climate dangers, and maintaining comfort and safety; hence, user-friendly environments are critical [4]. Few studies have investigated how climate change impacts construction and how to manage it [5–7], as well as resilience in existing buildings and measures to manage the impacts of climate change [8,9].

Previous studies have examined UK construction professionals' views and strategies for meeting the Paris Agreement's climate change goals using both qualitative and quantitative methods to identify effective approaches for mitigating and adapting to climate change in the industry [10,11]. This study highlights factors such as building age, location, and orientation, as well as environmental, financial, and policy factors that influence the impacts of climate change on UK residential buildings.

This study addresses the gaps in strategies for the UK to mitigate and adapt to climate change challenges [12]. It aims to identify measures to enhance the resilience of residential buildings against climate impacts. Thus, the following research questions (RQs) were posed:

RQ1. What are the views of construction professionals on the mitigation and adaptation strategies for the UK's residential climate-related challenges?

RQ2. What are the best strategies for reducing the impact of climate change and enhancing the resilience of residential buildings in the UK?

To investigate these RQs empirically, a contextual literature review is first provided, followed by the methodology used.

2. Perspectives of Literature

2.1. Impacts of Climate Change on Building Performance

The UK construction industry faces the profound challenge of the liveability of housing environments in reducing carbon emissions whilst meeting the increasing demand for buildings [13]. The Department for Communities and Local Government (2016) anticipated a population growth of about 14 million additional people by 2050, requiring an additional 3.2 million households by 2037 [14]. However, about 1.2 million people are on the waiting list for housing in a local authority as of 2017, with an additional 8 million homes needing urgent refurbishment to meet the looming risks of climate change impacts [15]. The threats to the built environment in the UK are diverse and include extreme natural hazards, such as floods and storms, and human-induced hazards; these hazards cause significant disruption to the economy and residents [16,17]. ShelterBox (2021) estimated that 167 million existing homes, the equivalent of every home in the UK, would be wiped out six times due to extreme weather globally, rendering more than 113 million people homeless due to disaster and conflict [18].

Flooding caused by storms Desmond, Eva, and Frank in the winter of 2015/2016 was predicted to cost GBP 1.6 billion [19]. ShelterBox (2021) and Collins (2019) imply that losing houses substantially impacts humans during the climate crisis, highlighting the need for further study in this area [18,20]. The National Housing Federation (2021) discloses an astonishing fact: in England, 25 million households generate a startling 58.5 million metric tons of CO₂, exceeding the 27 million automobiles that emit 56 million metric tons of CO₂ a year [21]. These data underscore the urgent need to educate homeowners about energy use and the profound impacts of climate change, as homes in England pose a more significant threat to climate issues than cars. Climate change impacts building performance and people, resulting in problems of internal environmental comfort, complete building damages, and

other issues that the world's building codes and practices attempt to protect [22]. It can be argued that it is relevant to assess the direct and indirect impact of climate change on buildings to determine if it is significant enough for change and adaptation implementation.

2.2. Construction Industry and Climate Change

The UK construction industry contributed GBP 117 billion (6%) to the national GDP in 2018 and employed around 2.4 million people in 2019 [23]. Hurlimann et al. (2019) opined that the construction industry is responsible for a large percentage of global greenhouse gas emissions, which has no evidence of adaptation and is subject to future climate change risks [24]. Hurlimann et al.'s study further shows that the construction industry only identifies the risk (which was downplayed) of extreme weather during construction (heat and wind), affecting the safety and occupational health, project delivery time, profits, and supply reliability. The effects of climate change pose further and more extensive changes in the form of storms, floods, rising sea levels, and temperature increases and are becoming increasingly evident worldwide, which have significant implications for how societies function, affecting both built and natural environments, as well as the health and wellbeing of people [25,26]. The construction industry, therefore, has significant potential to reduce emissions and to facilitate adaptation to climate change by looking for engineering solutions to limit the consequences of failure from severe weather, developing new ways of plan, designing and monitoring construction, and creating new skills and expertise at national and local levels to deliver climate resilience at smaller costs [27].

However, many countries' construction sectors, including the UK, are making efforts to mitigate the impacts of climate change. While implementation is hindered by financial and regulatory constraints, the potential benefits of overcoming these barriers are significant. For instance, Germany and Norway have implemented energy-efficient building standards and KfW Efficiency House Standards to decarbonise energy systems in buildings [28]. Despite these efforts, barriers such as the high political costs of retrofitting, the slow adoption of technologically sustainable construction materials, and the lack of awareness among construction professionals remain. However, if these can be overcome, the rewards will be immense [10,29,30]. Golubchikov and Badyina (2012) [31] argued that the construction sectors in developed countries face challenges in balancing environmental sustainability and urbanisation. This struggle is due to the inadequate enforcement of sustainable construction regulations, weak regulatory frameworks, and limited budgets [31]. Shah (2019) argued that the challenge of sustainable construction implies more than changing tools, technology, or energy-consuming materials; it means changing the mindset and attitude toward it [32].

The construction sector mainly builds residential and non-residential buildings (housing, hospitals, schools, and transport infrastructure) to meet human needs but at the expense of the environmental impacts of climate change [33–36]. It can be argued that more construction is expected worldwide due to population growth and economic expansion, resulting in more climate change impacts. Climate change impacts are considered the greatest threat to our environment because of their enormous environmental, social, and economic impact [37]. Therefore, the construction industry has been pressured to increase its practices' sustainability and resilience to tackle climate impacts and enhance building performance [36,38]. Climate change is primarily caused by the release of heat-trapping gases, mainly CO₂, produced by a wide range of human activities [39]. Siew (2021) supported the idea that climate change impacts will not stop for many centuries, though emissions have been curtailed [40]. Hence, the construction industry needs to develop practical, sustainable construction processes and create resource-efficient structures that are environmentally friendly throughout a building's life cycle [40].

2.3. *The Role of the Construction Industry in the Resilience of Houses*

It has been predicted that the world will experience more frequent occurrences of natural and extreme weather events due to the impacts of climate change [41]. Yang and Cheng (2020) explained that the world faces more uncertainties regarding disaster occurrence and social events, and resilience has been a topic of concern in recent years [42], such as infrastructure resilience [43], urban resilience [44], organisational resilience [45], and community resilience [46,47]. The construction sector is critical in enhancing the resilience of the liveable environment [48]. Wilkinson et al. (2016) and Sapeciay et al. (2017) demonstrated that the construction industry must first be resilient in itself, demonstrating quick responses, prompt disaster recovery, and reconstruction plans in order to be able to improve community and built environment resilience [49,50]. The construction industry contributes immensely to a country's economy and helps improve a community's quality of life and property to survive and thrive in a changing and uncertain environment [51]. However, many scholars define resilience in different ways [42,52].

This study has adopted the following working definition: disaster resilience is the systematic ability of a liveable environment to bounce back and forward in a timely and efficient manner and maintain its liveability despite the shock of hazards experienced due to climate change impacts. Building the resilience of a liveable environment early is cost-effective and saves lives and property. For example, DFID (2011) analysed the Disaster Risk Reduction work in Malawi and realised that for every dollar invested, net benefits of USD 24 were delivered to communities—improving food security while building their resilience to drought and erratic weather [52]. As a result, the construction team has a significant role in mitigating the impacts of climate disturbance. It is, therefore, of paramount importance for professionals to adhere to construction practices and building and technological codes in such a way that they can withstand a time of disaster, because poor planning and poorly regulated building codes worsen the impacts of hazards [53].

The more there is building resilience before disaster strikes a nation/community/environment/organisation, the less lasting damage is caused, and the quicker said entity recovers. Building resilience is of global importance to development, coping with and reducing the risk of climate change hazards and enhancing the capacity for speedy disturbance recovery. Although it can be argued that climate change hazards may only be avoided partially, their impacts can be rendered insubstantial. For instance, a catastrophic flooding experience in Bangladesh due to Cyclone Bhola took the lives of 300,000 to 500,000 in 1970; building resilience through preparedness, modern warning system facilities, and community cyclone shelters helped reduce the impacts of such occurrences in 2007 and 2009, where 3000 lives and 190 lives, respectively, were lost compared to the 1970 catastrophe [53,54]. Debatably, ignoring the warning of looming climate impacts on UK residential buildings means walking unprepared into catastrophic loss and damage, just as experienced in the COVID-19 pandemic. It is clear that urgent and collective action is needed to prevent these disasters.

In summary, a literature review of the impacts of climate change and resilience from the perspective of construction professionals has been provided. Indeed, as important as the work of construction professionals is, they are also responsible for most of the emissions that result from climate change conditions. Arguably, what was designed and built for the comfort of humanity has invariably resulted in consequences regarding the impacts of climate change. As a result, the construction professional is responsible for ensuring resilience in the built environments. Hence, this study of resilience and adaptation measures on UK residential buildings was conducted through the lens of a construction professional.

3. Research Methodology

This study used a qualitative approach within an interpretivist epistemological stance to provide insightful information from the perspective of construction professionals on the impacts of climate change on UK residential buildings. Maxwell (2015) opines that qualitative approaches pinpoint and facilitate the comprehension of the mechanisms underlying specific results [55]. Creswell (2014) opines that rather than just depending on the literature, respondents can express their thoughts about the topic under investigation using qualitative research [56]. The aim is to identify effective strategies for minimising the impacts of climate change and improving the resilience of residential buildings throughout the UK. Figure 1 illustrates the research process designed to achieve the aim of this study.



Figure 1. A graphical representation of the research process.

Semi-structured interviews were used because participants could be asked follow-up questions to share their opinions and explore how they understood the world [57]. Two-way communication during semi-structured interviews allowed for the development of fresh information and pertinent topics and respondents' ability to ask questions when necessary [58,59].

Each interviewee was sent an online Google form to complete the consent form and the participant's background. The three main elements of the interviews were the interviewee's background information, evaluation of the impact of climate change on residential buildings in the UK, and approaches to solving problems related to the topic. LinkedIn and recommendations from engineering professionals were used to identify the participants. The interviews were conducted through MS Teams platforms. The interviews were audio-recorded, transcribed, and assessed using NVivo 14 in different stages.

The interviews lasted an average of 45 min and were conducted using a pre-planned strategy to ensure that no important subjects were missed. The University of Wolverhampton Research Ethics Committee granted ethical approval, and each participant gave their expressed informed permission. Acknowledging the intricate relationship among policies, decision-making, and stakeholder perspectives, the interviews aimed to gain insight into the participants' practices, viewpoints, and mitigation strategies for climate change [60].

The use of purposive sampling, a method carefully selected to align the sample with the research’s aims and objectives, was instrumental in identifying a relevant population capable of addressing the research questions. This approach targeted participants from UK construction professionals, including engineers, industry academics, quantity surveyors, construction managers, and architects (Table 1). By focusing on this specific group, this study significantly enhanced the rigour and trustworthiness of the data and findings [61]. The participants, who possess considerable experience in the construction industry, provided valuable insights into strategies for mitigating climate change impacts and improving the resilience of residential buildings in the UK, thereby underlining the importance and relevance of this study.

Table 1. Background information of the respondents.

Respondent Code	Professional Body	Level of Education	Years of Experience	Company Sector
P01	Member of Construction Industry Council (MCIOB)	Postgraduate	6–10 years	Public
P02	Deep Foundation Institute	Postgraduate	6–10 years	Public
P03	ICE	Postgraduate	6–10 years	Public
P04	Member of Institution of Civil Engineers (ICE)	Postgraduate	6–10 years	Infrastructure
P05	Member of the Royal Institution of British ArchitectArchitects (MRIBA)	Postgraduate	11–15 years	Housing
P06	Royal Institution of Chartered Surveyors (RICS)	Masters	Under 5 years	Housing
P07	Member of Construction Industry Council (MCIOB)	Degree:	Under 5 years	Private industrial
P08	Member of the Royal Institution of Chartered Surveyors (MRICS)	Postgraduate	Over 15 years	Higher education
P09	Association of Project Management	Postgraduate	11–15 years	Public
P10	Institute of Environmental Management and Assessment	Postgraduate	6–10 years	Education

The thorough and rigorous participant selection process significantly improved the calibre and dependability of this study’s conclusions. Twenty UK construction professionals were contacted, with participants selected based on their work description [62]. The interviews were conducted until a saturation point was reached when no new information surfaced [63]. A study by Hennink, Kaiser, and Marconi [64] discovered that nine interviews produced code saturation. This study was guided by Saunders et al.’s (2017) description of data collection saturation, which is defined as “the extent to which new data replicate previous expressions [65] (p. 1897)”. The interviewees’ years of experience and membership in several professional associations showed that they had a very high understanding of the construction sector.

4. Results

The results discuss two main themes, which are as follows:

- (1) Impacts of climate change.
- (2) Measures to minimise the impacts of climate change.

4.1. Impacts of Climate Change

The respondents view the impacts of climate change in three categorical themes: impacts on UK residential buildings, residential building factors that determine their

vulnerability level, and impacts on occupants. The following discussion covers these theme categories because they are relevant to this study.

4.1.1. Impacts on UK Residential Buildings

The impacts of climate change on UK residential buildings are multi-faceted, including increased structural vulnerability, higher energy consumption, the need for retrofitting older buildings, increased risk of fires, faster deterioration of building materials, and a greater need for preventive maintenance. Addressing these challenges requires a comprehensive approach, focusing on resilience, sustainability, and proactive maintenance strategies. These reflect the impacts of climate change on UK residential structures. The subthemes related to the impacts of climate change on UK residential buildings are illustrated in Figure 2.

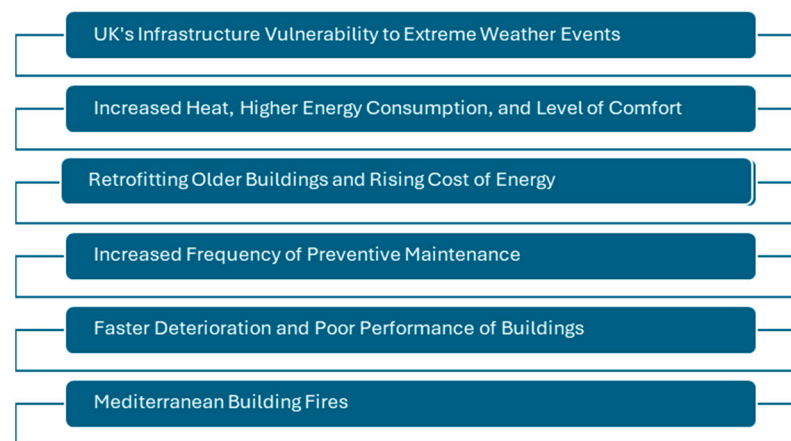


Figure 2. Impacts of climate change on UK residential buildings.

UK's Infrastructure Vulnerability to Extreme Weather Events [P01, P07, P08]: Increased risk of structural damage due to more frequent and severe flooding, warmer summers, and milder winters [3,66].

Increased Heat, Higher Energy Consumption, and Level of Comfort [P02, P01, P04]: Heatwaves lead to higher energy consumption. Emphasis on sustainable energy options like gas boilers and solar panels [67].

There are heatwaves in the summer; increased heat then leads to increased energy consumption [P01].

Previous research has highlighted the vulnerability of housing and its occupants due to high energy consumption, increased heating, and compromised comfort [68]. However, these findings contrast with those of Chen et al. (2021), who identified occupancy and interactions with buildings as key factors influencing increased energy consumption [69].

Heatwaves present significant challenges, especially in regions where infrastructure and housing are not designed to endure rising temperatures. This situation emphasises the need for proactive planning and design. Additionally, extreme heat events are not just uncomfortable; they primarily lead to weather-related fatalities [70]. This leads to adaptation measures to reduce energy consumption, as stated by P05:

“Keep in mind that climate change intensifies the use of solar power. Most UK houses now have solar panels on the roofs as alternatives to conventional energy use [P05]”.

Retrofitting Older Buildings and Rising Cost of Energy [P01, P06, P04, P03, P02, P05]: Climate change prompts energy efficiency improvements and the retrofitting of older buildings [71]. The respondents stated the need to retrofit older buildings with contemporary materials and technologies to improve their durability and usability, which is cost-effective, as stated by P02, “but also, we can see that a lot of the impacts of climate change, this reduction in temperature during the winter is also causing lot of owners of

older buildings to start thinking of how they can improve energy efficiency and insulate their buildings [P02]”.

Similar to Brough-Williams’ (2025) research, retrofitting may also involve upgrading HVAC systems, reinforcing structural elements, and incorporating smart building technology to monitor and manage building health proactively [72].

Mediterranean Building Fires [P02, P04]: Increased wildfires are linked to climate change, leading to building fires and greenhouse gas emissions [73]. This drier, hotter climate also creates conditions that fuel more vicious wildfire seasons—with fires that spread faster and burn longer, putting millions of additional lives and homes at risk [74].

Faster Deterioration and Poor Performance of Buildings [P07, P05, P02, P04, P01]: Older buildings in the UK are deteriorating more rapidly due to extreme weather conditions, which greatly affects their structural integrity [75]. The effects of carbon emissions and climate change are not limited to environmental concerns; they also have social and economic repercussions. Respondents highlight that the frequency of maintenance and retrofitting are on the rise, as stated by P05:

“But then, because of the intense weather extremes we are beginning to experience now, the damage will be quicker than it was ten years ago. So the fabrics of buildings deteriorate much faster [P05]”.

Increased Frequency of Preventive Maintenance [P01]: Due to accelerated wear and tear, there is a need for more frequent maintenance of building components, such as pipelines [76]. The respondents agree that regularly maintaining buildings is essential to increasing longevity and durability. However, Matthew (2024) argued that poor upkeep in buildings is often due to negligence, budget constraints, and lack of expertise, resulting in increased maintenance costs [77]. These costs are further affected by the increased frequency of maintenance, a result of the impacts of climate change. One of the respondents gave an example:

“Ten years ago, there was a significant difference in the lifespan of assets. For example, pipelines typically lasted around ten years before needing to be replaced or repaired. [P01]”.

Similarly, the UN Environment Programme (2024) states that the severity of climate change will lead to an increased frequency of disasters. For example, daily rainfall during extreme precipitation events is projected to rise by approximately 7 percent for each degree Celsius of global warming, which heightens the risk of flooding. This arguably results in needing frequent building maintenance [78].

4.1.2. Impacts on Occupants

Climate change significantly impacts occupants by forcing evacuations, deteriorating building materials, affecting health and well-being, and worsening air quality. Addressing these issues requires enhancing building resilience, improving sustainability practices, and reducing carbon emissions to mitigate the adverse effects on occupants.

Forced Evacuation Due to Climate-Related Events [P07]: High temperatures, floods, and high winds force people to evacuate their homes. Fires ignited by high temperatures also lead to evacuations [79]. People are forced to leave their homes due to the impacts of climate change on their residences, and in some cases, they might not go back again. Their historic lives are wiped out suddenly, which also impacts their physical and mental well-being. For example, P07 states the following:

“People have to evacuate their houses and properties due to flooding or high winds. Again, people have to evacuate their buildings because of the high temperature, which you know can, in turn, cause fires to ignite in the building and again cause people to evacuate the buildings as well [P07]”.

Environmental Consequences and Community Health and Well-being [P01]: Climate change accelerates the deterioration of building materials, reducing their lifespan and affecting community health and well-being. This necessitates more frequent maintenance and repair [79,80]. Experts argue that neglecting mitigation and adaptation maintenance will accelerate the problem and result in community health hazards, safety issues, functionality problems, and a reduction in air quality. This was mentioned by two interviewees, as follows:

“And I also see the same thing in the construction industry. Again, it affects health as well. You know, things like the community’s health or people living in those buildings [P01]”.

“Most people spend most of their lives indoors, and people who live in those buildings are also as affected as the designers. [P07]”.

These results correspond closely with the reports [3,81,82], indicating that increased carbon emissions trap heat, raising the Earth’s average temperature and deteriorating air quality; it increases exposure to hazardous wildfire smoke and ozone smog triggered by warmer conditions, both of which harm our health, particularly for those with pre-existing illnesses like asthma or heart disease [3,81,82]. For instance, in the summer of 2022 alone, thousands died in record-shattering heatwaves across Europe [83].

4.1.3. Factors That Influence the Vulnerability of UK Residential Buildings

Multiple factors influence the resilience of UK residential buildings to climate change, including building orientation, type, structural integrity, geographic location, and the quality of construction materials. Addressing these factors through improved design, construction practices, and material selection is essential for enhancing buildings’ resilience to climate-related impacts.

Building Orientation and Environmental Factors [P06, P01]: Buildings oriented towards the sun or prevailing winds experience more heat-related incidents and require more heating or cooling [84]. Some respondents stated below that building orientation and other underlying environmental factors contribute to residential vulnerability to climate change impacts, as stated by P01:

“So, where a building faces the sun or is oriented toward the sun, you expect to experience more heat-related incidents. If you are exposed to or are oriented in a place with prevailing winds, you might observe that you are exposed to more things like cooling or heating the mass. [P01]”.

Building Types and Structural Vulnerability [P01, P06, P07]: Different building types (detached, semi-detached, terraces) have varying vulnerabilities. High winds affect detached buildings more due to lack of support from surrounding structures. High-rise buildings withstand extreme weather better due to their structural integrity [85]. Building types and structural ability contribute to a building’s resilience to climate change impacts. Below is one respondent’s views:

“High-rise buildings, for example, may result in higher energy consumption and create areas with significant shade. Consequently, when it comes to heatwaves, you may not experience the same effects as in other environments. [P01]”.

The Interplay of Factors with the Age of the Building [P07, P08, P02]: Building type, materials, age, and technology influence how buildings respond to climate change. Older buildings with outdated materials and technologies may be less resilient [81,86]. As indicated below, the respondents suggested that these factors influence the level of building vulnerability to climate change impacts:

“All these factors, including the technology used in building materials, the age of the structure, and the maintenance of the property, significantly influence the environment

within a residential property. These elements clearly interact with each other at the level of the individual home. [P08]”.

Geographic Location and Climate Impact [P01, P05, P06, P07]: Buildings near water bodies are more prone to flooding and wind damage, and those near forests are at higher risk from wildfires [87]. Some respondents are concerned about residential buildings’ land allocations near areas prone to the impacts of climate change, such as flooding and wildfires. Building location is a significant factor affecting vulnerability to climate change. One respondent’s views shed light below:

“When it comes to building locations, proximity to water sources like rivers, streams, or the sea can increase the risk of flooding. Additionally, these areas are more vulnerable to strong winds and hurricanes, especially as climate change exacerbates these weather events. Conversely, properties situated near forests may be at greater risk during heatwaves, particularly if a fire occurs in the forest. [P05]”.

Building Fabrics, Materials Integrity, and Safety Suitability [P07, P05, P03, P04, P01, P06, P08]: Improved insulation materials lead to increased building safety and durability. Climate change has shifted from low-quality materials like asbestos to higher-quality, fire-resistant insulation [80]. This research also identifies building fabrics and material integrity, safety, and suitability, which impact building lifespan and performance. According to one of the respondents:

“Not just thicker insulation but also the type of material used in insulating buildings has changed over time due to climate change. This issue has led to increased attention on the quality of materials chosen for building insulation. [P04]”.

4.2. Measures to Minimise the Impacts of Climate Change

The respondents identified measures to be adopted to minimise the impacts of climate change on UK residential buildings. These are classified into three categories (the three Ps): personal role to minimise the impacts of climate change, professional responsibility, and policymakers’ role.

4.3. Personal/Community Role to Minimise the Impacts of Climate Change

Table 2 shows the theme “Personal/community role to minimise the impacts of climate change”, which is structured and covers the following sub-themes: community and property owner awareness and carbon offset. The interviewee informed the theme, which suggests that residents of UK residential buildings take part in addressing climate change crises.

Table 2. Personal role to minimise the impacts of climate change.

Themes	Personal Role to Minimise the Impacts of Climate Change Participant Summary	Participant Details	References
Community Awareness and Property Owner Education	P01 and P07 opine that educating the masses and building designers is crucial for fostering the adoption of low-carbon heating technologies and implementing effective climate change mitigation policies. Public education is key in empowering community members to understand flood risks and their impacts. Many property owners need to be made aware of these risks and the available flood risk reduction measures (P02, P03, P04). It is crucial to address the discomfort associated with transitioning to low-carbon heating technologies (P02) and to emphasise the role of community members in this process.	(P02, P03, P04, P01, and P07)	(Milne and Boardman, 2000) [88] (Verbong et al., 2013) [89]. Dubois et al., 2019) [90]

Table 2. Cont.

Themes	Personal Role to Minimise the Impacts of Climate Change Participant Summary	Participant Details	References
Carbon Offsetting Measures	<p>“To achieve net zero carbon emissions, it’s important to consider ways to offset carbon, such as planting trees. A reliable system for measuring carbon footprints is essential. This raises the question of how we can accurately and quickly measure the carbon footprint of a building and the total amount of carbon that has been emitted during its construction. If we can make these measurements as precise and straightforward as we do for our home’s heating or energy use, it will significantly aid in our efforts to reduce carbon emissions”.</p>	P04	(Too et al., 2024) [91]

4.4. Professional Responsibility

The participants indicated that construction professionals are responsible for tackling climate change and its impacts on UK residential buildings. This may be due to their contributions to carbon emissions and direct impacts on infrastructure.

This study identified 14 sub-themes contributing to the professional responsibilities that emerged from the interview transcript: Philosophical Shift in Building Design, Evacuation Planning, Dual/Holistic Approach for New and Existing Buildings through Collaboration, Sharing Best Practices, Enhanced Design Standards, Integration of Green Infrastructure, Smart Building Technologies, Carbon Offsetting Measures, Need for Embedding Climate Change in Training Programs, Continuous Improvement Through Research, Holding on to Traditional Practices and Limited Collaboration, Influence of Professional Bodies, Information Flow Across Construction Sectors (Conferences), and Alternative Awareness Approaches.

- Philosophical Shift in Building Design and Evacuation Planning [P08, P01]: There needs to be a shift in how buildings are designed and how evacuation plans are developed to better adapt to and protect against climate change. Long-term agreements, like those seen at COP 28, emphasise the need for resilience to climate change. Currently, the UK lacks effective evacuation strategies compared to places like the US [79].
- Dual/Holistic Approach for New and Existing Buildings [P01, P07, P06, P05, P04, P03]: Collaboration between the government and the construction sector is crucial for achieving sustainability and addressing climate change impacts. Both structural (e.g., building reinforcements) and non-structural measures (e.g., public awareness, flood warnings) are needed [79,91].
- Sharing Best Practices [P07, P01, P05, P02]: Construction professionals should actively share knowledge and collaborate with peers, industry experts, and organisations. This includes exchanging innovative practices, participating in joint projects, and leveraging interdisciplinary expertise to drive design, construction, and sustainability advancements.
- Enhanced Design Standards [P01, P03, P04, P07, P06]: Stricter design standards are necessary to ensure compliance with building codes and regulations, holding developers and designers accountable. This fosters transparency and a collective responsibility to create resilient built environments.
- Integration of Green Infrastructure [P01, P03]: Buildings should be updated regularly with materials that can withstand climate change impacts and integrate green infrastructure to improve resilience.
- Loosening Barriers and Reducing Damage [P02, P07, P80]: Reducing the damage from climate events, such as floods, involves using adaptable building materials and designs that allow for quick recovery and minimal disruption [91,92].

- Smart Building Technologies [P01, P03]: Smart technologies for the early detection of environmental disasters and effective communication systems are essential for preparing and evacuating occupants in emergencies [93,94].
- Carbon Offsetting Measures [P01, P02, P04, P06, P08]: Implementing measures to offset carbon emissions is important for mitigating climate change impacts.
- Embedding Climate Change in Training Programs: Climate change impacts should be embedded in the curriculum of degree programs related to building design and construction to educate future professionals.
- Continuous Improvement Through Research [P07, P05, P01, P02]: Ongoing research and knowledge sharing are necessary to improve practices and resilience in the built environment continuously.
- Retrofitting, Resilience Enhancement, and Sustainable Materials [P01, P02, P04, P06, P08]: Enhancing resilience and using sustainable materials in retrofitting projects are critical for adapting to climate change [95,96].
- Influence of Professional Bodies [P08, P07, P09]: Professional and accrediting bodies like RICS and CIOB play a significant role in shaping education and practices in the built environment [4,97,98].
- Information Flow Across Construction Sectors [P01, P02, P06, P07]: Conferences and other platforms are vital for networking and knowledge sharing between academia and industry professionals.
- Alternative Awareness Approaches [P08, P07, P05, P04]: Using traditional and social media to inform and educate the public about climate change impacts can inspire actions and understanding among the younger generations.

4.5. Policymakers' Role

The interviewees informed us of fourteen primary subthemes, six of which are briefly discussed below. According to the respondents, the following themes—shifts in mitigation strategies, political influence and policy implementation, community awareness and property owner education, proactive and performance-based approaches to climate change, retrofitting, resilience enhancement and sustainable materials and systems, stricter policy measures, integration of green infrastructure, proper land use planning, carbon offsetting measures, awareness versus implementation, retrofitting challenges, government incentives, and government action indicate the measures undertaken by policymakers to ensure residential buildings' strong resilience to the impacts of climate change.

Political Influence and Policy Implementation [P07, P06, P01, P04]: Legislative revisions are crucial to effectively mitigate climate change impacts, enforce higher performance standards, and drive reductions in carbon emissions [3,91].

Community Awareness and Property Owner Education: Property owners need education on understanding flood risks and the impacts of flooding. Many property owners in flood-risk areas are unaware and have not implemented necessary Property Flood Resilience (PFR) measures due to their lack of awareness.

Proactive and Performance-based Approach to Climate Change [P07, P06, P04, P03, P02, P05]: Addressing climate change requires proactive measures beyond short-term voluntary efforts. These alone are insufficient to achieve the necessary drastic reductions to meet the 1.5 °C goal set by the Paris Agreement [3,79].

Proper Land Use Planning [P01, P06, P07]: Proper land use planning is essential, supported by facilities and tools like elite load detections.

Awareness versus Implementation, Retrofitting Challenges [P01, P02, P03, P04]: While built environment professionals are aware of the impacts of climate change and the potential

damage of their activities, implementation challenges exist, particularly in retrofitting existing buildings [99].

Government Incentives [P01, P02, P03, P04]: The government should provide incentives to construction companies and those taking steps to address climate change. This support can include research funding and informing construction firms about best practices [100,101].

5. Discussion of Results

5.1. Construction Professionals' Views That Influence Mitigation and Adaptation Strategies for the UK's Residential Climate-Related Challenges

The findings from this study show that the respondents recognise the impacts of climate change on UK residents and residences, which are largely influenced by various building factors and environments. The respondents also agree with the existing literature [39] on the primary drivers of climate change, particularly the emission of CO₂. This emphasis on CO₂ emissions underscores the urgency and importance of addressing this issue, as it leads to various changes in climatic systems, such as temperature and sea level rises. Carbon dioxide (CO₂) is the most prevalent emission due to its abundance and ability to linger in the atmosphere for thousands of years [102]. Knowing the root cause of climate change is essential to responding appropriately and solving the impacts on UK residential buildings. In many industrialised nations, the construction sector is one of the significant energy end-use sectors, contributing more to overall energy consumption than other industries [103]. A large proportion of greenhouse gases is emitted in developed countries through the construction sector's activities [104,105].

Respondents in this study highlighted the increasing significance of climate change-related phenomena, such as flooding, heavy rainfall, drought, sea rise, fire risk, and higher temperatures. These issues align with the existing literature, which notes the adverse effects of extreme weather events on historic and residential buildings, leading to material decay and structural damage [106]. Climate change has increased the frequency and intensity of extreme weather events, posing significant risks to the environment, housing infrastructure, and public safety [66]. Adaptation and resilience measures are urgently needed to mitigate these risks and ensure residents' safety and well-being [61]. The respondents also highlighted various residential building factors, such as age, location, orientation, material and structural integrity, and building types, contributing to vulnerability to climate change's impacts on UK residential buildings and their occupants. Jurgilevich et al. (2023) highlighted various factors of climate change that impact the health of the building occupants [107].

The respondents acknowledged the need to upgrade older buildings to enhance energy efficiency and decrease carbon footprints. Retrofitting is a crucial tactic to improve an existing structure's performance without demolishing and building new ones [103,104]. This strategy conserves resources and minimises waste, making it suitable for sustainability [71]. The rates at which building elements deteriorate can be traced to the inherent characteristics of building materials and the impacts of climate change and anthropogenic activities [108]. Effectively managing these impacts requires long-term planning and understanding of the additional maintenance needed to address climate change [80]. Carbonation-induced corrosion, a primary cause of structural deterioration, must be addressed to maintain building strength [109]. The building industry significantly impacts environmental deterioration through waste generation, energy use, gas emissions, and resource depletion [109]. While some argue that climate change consequences are negligible compared to urbanisation and economic expansion, most agree that climate change poses the greatest environmental threat this century [79].

5.2. The Perceived Best Strategies for Reducing the Impact of Climate Change and Enhancing Resilience in UK Residential Buildings

Addressing the impacts of climate change on the built environment requires comprehensive strategies, including retrofitting, effective maintenance, and resilient construction practices [95,96]. The building industry must adopt sustainable practices to mitigate its environmental impact and adapt to the changing climate. By implementing these strategies, the longevity and safety of our built environment can be ensured while contributing to global efforts to combat climate change. Some interviewees agree with the literature that the impacts of climate change would reduce the comfort of the occupants of UK residential structures due to higher heat and energy consumption, which might be fatal [18,20,22]. This study uncovers the multifaceted challenges faced by residents due to the impacts of climate change. They highlight effective strategies and best practices to be adopted by construction professionals and personal/community and policymakers. The findings from this study underscore the need for collective action to address the impacts of climate change on UK residential buildings. This shared responsibility extends to policymakers, construction professionals, and individuals in their personal and community roles. It was established that carbon offsetting is everyone's responsibility. We can make a significant impact by working together and sharing the burden. Educating property owners and providing training to increase awareness of climate change is a collective responsibility in which we must all participate.

A comprehensive strategy incorporating knowledge-sharing platforms with policy tools (laws and incentives) is essential to shift industrial culture and social habits toward a low-carbon future. For example, carbon taxes can encourage sustainable choices and internalise environmental costs. These taxes and well-crafted incentives can promote behaviour changes [91]. Government incentives and regulatory programs, like retrofitting initiatives in the UK, have been instrumental in driving positive changes to tackle the impacts of climate change on UK residential buildings [110]. Government policies, actions, and implementations are crucial for ensuring proper land planning and usage, enhancing resilience, and improving adaptation and mitigation efforts [111,112]. However, a notable gap exists between governmental commitments to combat climate change and tangible actions to reduce greenhouse gas emissions [3]. Natural flood management strategies, such as restoring natural areas, are robust alternatives to traditional flood defences like walls and barriers. These strategies include soil and peatland replenishment, tree planting, river flow restoration, beaver reintroduction, and enhancing water storage capacity [79].

Robust public awareness campaigns can further enhance the effectiveness of promoting sustainable practices [113]. A holistic approach that considers social and behavioural aspects is increasingly essential. Enhanced design standards and stricter policy measures are critical as these factors significantly influence technology adoption and measure efficacy [91]. Recognising these limitations, there has been a transformative shift towards performance-oriented frameworks prioritising desired outcomes over rigid specifications [91,92]. This shift allows for greater flexibility, encourages innovation, and facilitates the exchange of best practices on a global scale, inspiring a new era of architectural excellence [79]. Crosbie (2024) recommends that homeowners and young residents in a growing community utilise green financing to promote climate and sustainable housing solutions [74].

This can be achieved through green home loans/mortgages and incentives that allow for the incorporation of solar panels, energy-efficient appliances, and smart building technologies, such as flood detection, emergency response systems, and effective sensor networks within the building, which are essential for managing these sustainable features autonomously [74]. A highly efficient and well-managed sensor network may collect and

process field data to provide high-quality, usable information [93]. Individually, built environment professionals play an important role in climate adaptation, from analysing risks to built assets and developing action plans to designing structures that can withstand the effects of extreme weather and funding additional resilience measures for communities [4].

6. Conclusions

This study provides a detailed analysis of construction professionals' perspectives on mitigation and adaptation strategies to enhance the resilience of the UK's residential buildings and their occupants. It identifies the most effective methods for reducing the impact of climate change and improving the resilience of UK residential buildings. The findings contribute to the current body of knowledge and propose practical, strategic measures that can be implemented to mitigate these impacts in the real world.

Respondents acknowledged that CO₂ emissions are a primary driver of climate change and recognise that professionals' design and construction practices significantly contribute to these emissions. This, in turn, affects the performance and sustainability of the buildings they construct, creating a ripple effect throughout the built environment. This study highlights several barriers that hinder practical mitigation efforts by construction professionals:

- **Policy and Legal Constraints:** Existing policies and regulations often do not support innovative mitigation strategies.
- **Financial Limitations:** insufficient funding and financial incentives restrict the implementation of advanced mitigation measures.
- **Resource Availability:** limited access to sustainable materials and technologies.
- **Ageing Infrastructure:** Older residential buildings pose significant challenges due to outdated designs and materials.
- **Building Types and Locations:** variations in building types and geographical locations affect the applicability of uniform mitigation strategies.
- **Technical Expertise:** poor technical know-how and collaboration among professionals hamper progress.

This study emphasises the collective responsibility of individuals, communities, construction professionals, and legislators to raise awareness, implement solutions, and take action to mitigate the effects of climate change. Professionals, in particular, bear a significant portion of the workload, from designing intelligent buildings to integrating electronic gadgets and green infrastructure. This study suggests several strategic recommendations to address these challenges:

- **Philosophical Shift in Design:** emphasising sustainable and resilient building designs.
- **Strategic Evacuation Planning:** developing plans to ensure safety during extreme weather events.
- **Integration of Green Infrastructure:** incorporating nature-based solutions to enhance resilience.
- **Identifying and Overcoming Barriers:** addressing policy, financial, and technical barriers.
- **Carbon Offsetting Measures:** implementing strategies to offset CO₂ emissions.
- **Training and Continuous Improvement:** embedding climate change education in training programs and promoting continuous research and retrofitting efforts.

This study underscores the importance of policy in incentivising homeowners to enhance existing buildings' resilience and adaptive features. In collaboration with construction professionals and communities, policymakers can disseminate practical information about climate change impacts and mitigation measures. This collective effort is crucial for increasing the awareness and understanding of climate change.

Addressing climate change in the construction industry requires a multifaceted approach involving effective government policies, public awareness, innovative technologies, and active participation from professional associations. By adopting these comprehensive strategies, the industry can significantly contribute to a sustainable, low-carbon future. This study provides valuable insights and actionable recommendations for enhancing resilience and adaptation measures in UK residential buildings.

7. Limitations of This Study

The data collection was from ten UK-based construction professionals only. The qualitative approach of this study suggests that the results may need further investigation through mixed methods to fully understand the subject matter of the topic. However, the potential impact of this study's findings on guiding future decisions regarding the resilience and adaptation measures of residents and residential buildings in other parts of the world is significant. This study's limitation is that it focused on professionals' perceptions of resilience and adaptation measures for UK residences and residential areas. While this study did not use instruments to measure these impacts, the valid opinions of the professionals are acknowledged and respected. Consequently, more research is required to create a framework for measuring the effects of climate change.

8. Further Recommendations

Future research might build on the robust findings of this work to provide an approach/methodology to improve existing residential construction building practices. The following recommendations are made for policymakers, construction industry experts, and the community based on this study's findings:

- The government's role in offering financial incentives through suitable policies is crucial. These incentives can motivate the end-user to adopt climate-friendly practices, thereby lessening the drivers of climate change from residential buildings and achieving adaptation and mitigation measures.
- The government should assess and identify high-risk areas vulnerable to climate disasters and enforce climate-adaptive building policies to promote awareness creation and ensure residential building resilience.
- The government, construction bodies, professionals, and communities should unite and collaborate to find a way to present resilience in residential buildings and ensure the safety of the occupants from the impacts of climate change.
- The construction professional bodies should be strongly involved in fighting climate change's impacts on UK residential buildings.
- The community, government, and construction professionals should educate homeowners to raise awareness of how to make their buildings resilient to climate change impacts.

The building sector can ensure climate change resilience and significantly reduce its environmental impacts by addressing these barriers and implementing global best practices.

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