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A Framework to Minimise the Impacts of Climate Change on UK Residential Buildings and Occupants

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Abstract

Residential buildings, the bastions of shelter and protection, are facing an escalating threat from climate change. The need to bolster the resilience of UK residential buildings is becoming more urgent, given the nature and frequency of the impact of climate change. This study employed a sequential explanatory mixed-method approach. The first phase involved surveying 313 households, revealing that Climate Change on Buildings (CCB) and Climate Change Measures (CCM) significantly influenced Climate Change on Occupants (CCO). Moreover, climate-positive measures were found to have a significant impact on building occupants. The second phase involved semi-structured interviews with ten UK construction experts to gather insights into the effects of climate change on residential buildings and strategies for mitigation. The findings from both phases underscore the need for government incentives, green loans, and increased stakeholder awareness to mitigate the impacts of climate change. To fully address climate change and improve the quality of life for residents, all stakeholders, including policy makers, construction professionals, and the community, must participate actively in these efforts. Consequently, a framework was developed to minimise the impacts of climate change on UK residential buildings.

Keywords: UK; residential homes; climate change; measures; framework; construction professionals; policy makers; communities



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1. Introduction

As climate change continues to fuel a relentless surge in heat waves, the impact on residential buildings and the health of occupants, particularly those with limited control over their environment, such as the elderly, infants, individuals living alone, and the sick or bedbound, is escalating in severity [1,2]. This urgent situation necessitates using energy-intensive mechanical cooling systems, which regrettably contribute to climate change through greenhouse gas emissions [3].

Dino and Meral Akgül (2019) projected that the severity of climate change impacts will primarily target the built environment, posing a significant threat to both indoor and outdoor activities [4]. This could lead to occupant discomfort, health issues, decreased productivity, and potential displacement. Onus, Chinyio, and Daniel (2024b) further demonstrate that climate stressors reduce the resilience of UK residential buildings, increase maintenance needs, and diminish occupant well-being [5].

Murray and Ebi (2012) have posited that climate actions, including mitigation and adaptation, play a crucial role in reducing the consequences of global warming on buildings, given their long lifespan characteristics [6]. According to the Intergovernmental Panel on

Climate Change (IPCC) (2017), adaptation involves planning and actions to enhance resilience and reduce vulnerability to the anticipated impacts of climate change [7]. Resilience, as described by the IPCC (2007a) and Kate & Griffin (2020), is the capacity of a system to absorb disturbances while maintaining its core functions and adapting to change [8,9]. This underscores the potential for positive change through proactive measures to address climate change in the context of residential buildings.

In the UK context, vulnerability denotes the extent to which residents and dwellings are exposed to and unable to manage climate-related hazards [8,10]. The Environment Agency (2021) emphasises the importance of enhancing national resilience to climate emergencies, such as flooding, alongside efforts to reduce emissions [11]. Van Hooff et al. (2015) emphasise that both new and existing buildings must adapt to maintain healthy indoor environments with reduced energy consumption [12].

Contrarily, Patidar et al. (2014) argued that climate change could enhance building performance by providing thermal comfort to occupants [13]. However, Hamdy et al. (2017) highlighted that overheating in buildings will pose significant issues as the UK becomes warmer, causing thermal discomfort, illnesses, and increased mortality rates [14]. This research contributes to the growing body of knowledge by providing a framework to mitigate the climate impacts on UK residential buildings. Drawing on recent empirical insights, it aims to develop positive practical measures for adaptation and resilience [15,16]. The framework aims to unite academics, construction professionals, policy makers, and communities by providing the data needed to understand the effects of climate change on residents and their homes. It offers a template for identifying actions that can be taken to mitigate these climate impacts. Thus, these research questions (RQ) were posed:

1. Do climate measures have an impact on residents and residential buildings?
2. What are the measures for ensuring residential buildings' resilience to the impacts of climate change?

Although empirical findings have been published and are presented in this manuscript, the purpose of this paper is to develop a framework of actions/interventions to minimise the negative impacts of climate change on UK residential buildings and their occupants.

2. Literature Review

Boumans et al. (2020) stated that climate change would ill affect the health and well-being of people directly and indirectly, of which 600 million of these people live in a 'low-level coastal zone' and 200 million on a coastal flood plain [17]. The Climate change effect is already experienced in the quality of air, safety of clean water supply, frequent extreme weather events, chronic disease, drought and food insecurity [18]. Met Office (2020) asserted that 39% of people who live around 100 km from the shoreline are at risk of flooding due to sea-level rise, causing costly building and transportation damages [19]. It can be argued that climate change impacts add more stress to communities or countries that are more at risk, such that hot countries experience more heat and places suffering regular flooding are at more risk of flooding; all these could in anyway destruct access to food production, transport network, good health, and access to essential social amenities.

2.1. Impact of Climate Change on Buildings and the Environment

The built environment is highly vulnerable to climate change, particularly from flooding, storms, and extreme weather, which accelerates the deterioration of structures and materials [20,21]. Events such as heavy rainfall and storm surges can compromise building integrity, leading to contamination and higher energy demands for cooling, thereby increasing operational costs [22]. Urbanisation amplifies the effects of heat in cities, un-

underscoring the need for retrofit strategies that prioritise both thermal efficiency and flood resilience [23].

Climate adaptation presents both risks and prospects. Consequently, building design must now integrate climate data to bolster resilience and sustainability [24]. The UK's target to reduce greenhouse gas emissions by 81% by 2035 requires retrofitting approximately 25 million homes, which account for 15% of CO₂ emissions, mainly from heating [25]. The urgency of decarbonisation is reinforced by projections of more intense storms and heat waves [26]. With over 90% of building-related emissions in OECD countries stemming from energy use [5], the construction industry holds a pivotal role in this transition.

Mitigation efforts must consider the whole building lifecycle from design to occupancy and the behaviour of occupants [27]. As HM Government (2010) noted, the performance of even a well-designed building can be undermined by poor management, affirming the importance of holistic planning [28]. Buildings and climate change affect people both directly and indirectly through indoor air quality, temperature control, and physical comfort. This interconnectedness underscores the lasting impact of the built environment on public health.

Most individuals in developed nations spend over 90% of their time indoors (Islam and Winkel, 2017) [29]; in the UK, this figure rises to 95.6%, with 66% of that time spent at home (Schweizer et al., 2007) [30]. Vulnerable groups including the elderly, children, and individuals with health conditions may spend nearly all their time indoors [31]. Thus, further research is essential to understand how climate change affects indoor environments and, by extension, occupant well-being, comfort, and mental and physical health [32].

2.2. Building Characteristics and Occupant Behaviour

Climate projections underscore the need to improve building insulation to reduce emissions and enhance sustainability. Performance varies by location, weather, occupancy, and material quality [33]. In the UK, high air permeability necessitates sealing measures to reduce heat loss and improve thermal comfort, especially in winter [34]. However, increased airtightness can elevate indoor pollutant levels, necessitating the use of mechanical ventilation and filtration systems [33]. Without adequate cooling, buildings risk overheating in summer [34]. Homes built between 1930 and 1980 often exhibit greater variability in air permeability than newer constructions [35]. High thermal mass can buffer temperature extremes but may trap heat, making night-time cooling essential [35].

Occupants play a critical role in regulating indoor environments through adaptive behaviours such as window use and heating adjustments. These behaviours are shaped by demographics, income, health, and awareness [36–38]. Designing climate-resilient homes must therefore integrate occupant behaviour into adaptation strategies. Onus et al. (2025b) emphasise the importance of multi-stakeholder collaboration, including housing owners, community members, construction professionals, and policy makers, in enhancing building resilience [38].

Adapting the Built Environment

Adapting buildings to climate change is both an environmental and societal imperative. Retrofitting older structures and designing new buildings with low-carbon materials, advanced ventilation systems, and passive cooling strategies are essential for enhancing resilience [39,40]. Passive measures such as solar shading and tree planting can reduce reliance on air conditioning [39]. Dwyer (2018) confirms the effectiveness of solar shading, but integrated approaches combining design and behavioural adaptation are most effective [41].

Hajian and Kashani (2021) define sustainability as “the ability of a society, ecosystem, or other interactive system to continue functioning without depleting vital resources or negatively impacting the environment” [42]. In the UK, buildings account for nearly 50% of total energy demand and associated CO₂ emissions, primarily from electricity, heating, cooling, ventilation, and lighting [43]. Getvoldsen et al. (2024) underscore the interdisciplinary nature of sustainability and climate change, advocating for their joint consideration—particularly in relation to energy use—rather than treating them as isolated domains [44].

Air-source heat pumps (ASHPs) offer a promising low-carbon heating solution for urban residential areas. However, their deployment can introduce acoustic challenges, especially in high-density housing where spatial constraints limit installation flexibility. For instance, an ASHP installed at the rear of a central terraced house, less than five metres from a neighbouring window, recorded the highest noise levels ever measured [45].

To mitigate such disturbances, sound insulation hoods have proven effective, reducing noise emissions by up to 15 dB(A) and helping meet environmental noise standards [45]. However, technical fixes alone are insufficient. The strategic placement of ASHPs—away from acoustically sensitive areas, such as bedrooms and living rooms—must be embedded within broader planning frameworks. This includes integrating noise mitigation into building codes, urban planning policies, and retrofit guidelines to ensure equitable and sustainable deployment [46,47].

Equally important is the social dimension of ASHP implementation. Transparent consultation with neighbouring residents can foster community acceptance and prevent conflict [48]. Onus et al. (2025b) emphasise the value of stakeholder engagement and participatory governance in addressing climate-related challenges in UK residential buildings [38]. A comprehensive strategy that balances technological innovation with social cohesion and spatial equity is crucial for the successful deployment of ASHP [48].

2.3. Economy Cost of Climate Change

Climate change remains a pressing global concern. In 2018, 315 climate-related disasters including wildfires, storms, droughts, and floods were recorded worldwide, emphasising the urgency of this issue [49]. Between 2017 and 2019, 125 extreme weather events resulted in economic losses of approximately \$943 billion [49]. In 2019 alone, 95 million people were directly impacted, threatening ecosystems and vital resources such as food and water and increasing the risk of inter-group conflict.

The consequences of extreme weather are evident in both direct economic losses and broader impacts on GDP [50]. Jahn (2015) distinguishes immediate damages such as loss of life and property from indirect disruptions caused by broader economic systems [51]. For example, Storms Ciara and Denis in 2020 prompted insurance claims exceeding £360 million, affecting over 82,000 people, with 64,300 related to home damage [52].

Table 1 summaries the estimated financial damages and the number of properties affected by significant flooding events in the UK. According to the Environment Agency, the floods of Winter 2015–2016 caused slightly greater losses than those in 2013–2014, with a best estimate of £2.09 billion. These floods affected approximately 21,000 properties and had a broader geographic impact [53].

Droughts may be even more economically damaging than floods or earthquakes [54]. Climate change heightens flood risk, threatening the liveability of homes and infrastructure [55]. Approximately 1.3 million people in England one in six homes face significant flood risk, with £275 billion in property potentially affected [56]. To mitigate this, the agency has committed £5.2 billion to protect 336,000 properties. According to the National

Audit Office, flood prevention is highly cost-effective, with £1 in prevention saving £8 in future damages [57].

Table 1. 2015–2016 economic damages by flood impacts, Adapted from Environment Agency (2020) [56].

Event	Min Damages Estimate	Best Damages Estimate	Max Damages Estimate	Approx Number of Properties Flooded
Summer 2007	£3.75 billion	£4.80 billion	£5.70 billion	48,000 residential, 7000 businesses
Winter 2013–2014	£1.31 billion	£1.70 billion	£1.96 billion	10,500 residential, 3100 businesses
Winter 2015–2016	£1.69 billion	£2.09 billion	£2.47 billion	16,000 residential, 5000 businesses
January 2016–November 2019 total	£504 million	£708 million	£924 million	8700 residential, 1200 businesses

2.3.1. Social Effect of Climate Change

Stewart (2021) highlighted the urgent need to adapt to and mitigate climate change's impacts on social, economic, health, and environmental dimensions [58]. Climate change-induced alterations in socio-structural conditions, uncomfortable living environments, and escalating poverty can lead to societal conflicts [59]. Extreme climate events like floods, storms, heavy precipitation, and droughts pose significant threats to both people and ecosystems, necessitating that built environments develop effective mitigation [59,60].

Boda (2019) stresses that researchers are increasingly concerned about the economic and non-economic losses caused by climate change [61]. The impacts of climate change on buildings can be categorised into several key areas: structural integrity can be compromised by floods, landslides, and storms; construction elements may be affected by water supply and fastening systems; and building materials and indoor climates can suffer from variations in humidity and temperature [12].

2.3.2. Psychological Effect of Climate Change

Low-income households are disproportionately exposed to climate risks. According to the Energy & Climate Intelligence Unit (2021), they are eight times more likely to reside in tidal floodplains than wealthier households, with 61% lacking insurance leaving them vulnerable to severe financial losses in the event of flooding [62].

Climate change impacts extend beyond physical damage. Exposure to events like floods and storms can have lasting psychological effects, including anxiety, grief, fear, and trauma [63]. These effects are compounded by physical threats such as droughts, wildfires, rising temperatures, and environmental degradation, all of which influence both human mental and physical health [64]. Mah et al. (2020) emphasise that climate change will increasingly drive psychological stress in future societies [65]. Doherty and Clayton (2011) further highlight that vulnerable populations suffer direct and indirect mental health consequences, which can also spur mitigation efforts [66].

The social consequences may be even broader. Ranson (2014) found a strong correlation between rising temperatures and increased criminal activity, forecasting significant upticks in violent and property crime by 2099 due to climate-induced stress and instability—22,000 murders, 180,000 rapes, and millions of assaults, robberies, and thefts in the United States alone [63]. If these trends persist, climate change could also become a catalyst for civil unrest and conflict.

3. Research Methodology

Primary data were collected through a mixed-methods research approach, including a quantitative explanatory study with stakeholders and a qualitative descriptive study with construction professionals. Firstly, UK occupants ($n = 313$) were surveyed using an online questionnaire to assess their perceptions and experiences of climate change impacts on their residential buildings. The research focused on residential buildings vulnerable to

climate change's impacts. Sampling is selecting a portion of a population that accurately reflects the entire population, such as random, systematic, convenience, clustered, and stratified [67]. Hence, it is important to select an adequate sampling technique for the study [68,69]. The participants for this quantitative study were randomly selected from UK households deemed vulnerable to climate change [70]. Secondly, UK construction professionals ($n = 10$) involved in the UK construction sector were interviewed, with questions used to explore their views and opinions regarding the impact of climate change on residential buildings as shown in Table 2. Purposive sampling is specifically chosen to identify a relevant population that could effectively target participants from the UK construction sector, including engineers, industry academics, quantity surveyors, construction managers, and architects.

Table 2. Research method.

	Sequential Explanatory Mixed Method		
	Quantitative	Qualitative	Validation (Qualitative)
Strategies	Online Survey	Semi structured interview	Semi structured interview
Sampling	Random	Purposive	Purposive
Analysis	Descriptive and Inferential	Thematic analysis	Thematic analysis
Tools used	SPSS (V.28), Data tab, excel, word	NVivo (V.14), excel, word	NVivo, excel, word
Sample size	313 participants	10 experts	7 experts
Data type	Statistical, numeric data/text	Context View	Context View
% of survey returned	60%	50%	41%
% of properly completed surveys	56.90%	50%	41%

3.1. Data Analysis

Analysis of Quantitative Responses

Tables 3 and 4 summarises the results of a linear regression analysis output examining the effect of CCM (Climate Change Measures) on the dependent variable CCO (Climate Change on Occupants).

Table 3. Regression Results.

Metric	Value	Interpretation
R	0.575	indicating a moderate positive relationship between CCM and CCO.
R Square	0.331	suggests that approximately 33.1% of the variance in CCO can be explained by CCM.
Adjusted R Square	0.328	Adjusted for number of predictors (only one here), still strong.
F Change/Sig. F Change	153.543/0.000	Indicates that the overall regression model is statistically significant ($p < 0.001$).
Note		The model is a good fit, explaining a significant portion of the variation in CCO with statistically significant predictors.

Table 4. Result of Regression analysis.

ANOVA Table					
Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	24.645	1	24.645	153.543	<0.001
Residual	49.917	311	0.161		
Total	74.562	312			
Coefficients Table					
Variable	B (Unstd.)	Std. Error	Beta (Std.)	t	Sig.
Constant	1.067	0.195	—	5.484	0.002
CCM	0.62	0.05	0.575	12.391	0.002

3.2. Hypothesis for the Quantitative Surveys

Hypothesis 1(H₁): *Climate measures/policy have a significant impact on residential building occupants.*

More precisely, the null hypothesis that the coefficient of (Constant) is zero in the population was rejected. The results clearly depict that the CCM positively affects the occupants (CCO). The results clearly depict that climate measures have a positive effect on occupants as illustrated in Table 4.

3.3. The Collection and Analysis of Qualitative Data

The qualitative data for this study was collected using a semi-structured interview format with ten professionals in the UK construction industry using the team online platform. The collected video data was first converted to mp3 format and copied to MS Word for transcription. The researcher then enters back and forth the transcribed data for cleansing and editing before presenting it in NVivo software (V.14) for coding and categorisation. After additional categorisation, the coded data was uploaded to an Excel sheet to identify sub-themes.

3.4. The Development of the Framework of Measures to Minimise the Impacts of Climate Change on UK Residential Buildings and Occupants

A structured framework was developed through an extensive screening and selection process to identify components uniquely relevant to the UK construction sector's climate change response. Drawing on both qualitative and quantitative research as well as a comprehensive literature review, the framework organises tools and methodologies into key focus areas with actionable subcategories ensuring systematic implementation by stakeholders.

Designed to integrate the contributions of communities, construction professionals, and policy makers, the framework supports adaptation across diverse UK regional and socioeconomic contexts (see Figure 4). It enables local actors to assess physical and economic vulnerabilities and identify resilience-building pathways. The main objective is to help the construction sector and government anticipate climate challenges, foster innovation, and adopt flexible, forward-looking responses.

The framework functions as a practical and adaptable guide, promoting intersectoral collaboration and the consistent adoption of best practices. It grounds the research within established theory, clarifies the scope of the problem, and informs research questions. Ultimately, it equips decision-makers with both conceptual understanding and implementable strategies to address climate impacts on UK residential buildings.

3.5. Expert Consultation and Framework Validation

Semi-structured interviews were conducted with seven professionals from the construction industry, climate change experts, and academics to assess the framework's robustness, applicability, and practicality in mitigating the impacts of climate change on UK residential buildings. This qualitative method enabled the provision of tailored feedback grounded in real-world industry practices and revealed areas that required refinement.

3.6. Validation Survey of the Framework's Effectiveness

To validate the framework's effectiveness, a survey was administered, aligning with Hassan's (2024) definition of research validity, which is the degree to which a study accurately measures its intended outcomes and reflects real-world conditions [71]. Seventeen UK construction professionals were purposively selected based on job role, prior engage-

ment in the study, and relevant experience. The framework was distributed via email, LinkedIn, and WhatsApp.

Participants responded to twelve open-ended questions—four demographic-based questions and eight questions on evaluating the framework’s relevance, comprehensibility, feasibility, limitations, and suggestions for enhancement.

3.7. Validation Survey Responses

A 41% response rate resulted in feedback from seven experienced professionals. Table 5 provides background information on these participants, detailing their professions, roles or specialties, years of experience, and the sectors in which they operate. Their insights, drawn from extensive knowledge, offered constructive recommendations that confirmed the framework’s applicability. The sectors represented are primarily housing-related (e.g., residential development, housing repairs, and maintenance) but also include infrastructure and the public sector. Notably, one participant, a university lecturer, contributed insights from an academic and research-driven perspective, complementing the predominantly practice-based backgrounds of the other participants.

Table 5. Respondents’ demographics.

S/N	Please State Your Profession:	Role/Specialty:	Years of Experience:	Sectors
1	Senior Human Factors Consultant	Health and Safety in Construction and Climate Resilience	Over 15 years	Housing, Infrastructure, Public, Housing Repairs and Maintenance
2	Site Manager	Site Manager	Under 5 years	Housing
3	Construction	Site Manager	6–10 years	Housing
4	Architect	Senior Technical Coordinator	11–15 years	Housing
5	Assistant site manager	externals	Under 5 years	Housing
6	Design manager	Design	Under 5 years	Housing
7	University lecturer	Engineering and Risk Management	6–10 years	Public

4. Results

The findings indicate that climate change measures (CCM) significantly influence the experiences of building occupants. The model demonstrates a good fit, successfully explaining a substantial portion of the variance in occupant behaviour. The coefficients obtained are statistically significant, affirming the impact of CCM on building occupants. These results suggest that addressing climate change impacts and implementing effective climate mitigation measures can have a positive impact on the occupants of a building.

4.1. Measures to Minimise the Impacts of Climate Change

The respondents were asked to identify resilience and mitigation measures to minimise the impacts of climate change on residential buildings. Therefore, to better understand the measures, three roles were identified: personal role to minimise the impacts of climate change, professional responsibility, and policy makers’ role. The themes formed were classified as shown in Figure 1 below.



Figure 1. Measures to minimise the impacts of climate change.

4.2. Personal/Community Roles in Minimising the Impacts of Climate Change

This subsection explores two sub-themes: community awareness and property owner education on carbon offsetting to encourage occupant participation in addressing climate change impacts on UK residential buildings. Respondents highlighted the importance of educating end users to foster understanding and action: Raising public awareness is viewed as a necessary first step, placing responsibility on individuals to understand climate-related risks to both buildings and occupants, as suggested by [P07].

4.3. Professional Responsibility to Minimise the Impacts of Climate Change on the UK Residential Buildings

Respondents highlighted that construction professionals hold the primary responsibility for addressing the impacts of climate change on residential buildings in the UK, as shown in Figure 2. These actions involve implementing sustainable building practices and complying with regulations designed to minimise environmental impact. Furthermore, training and awareness are essential for these professionals to stay informed about best practices and innovations in eco-friendly construction, according to the respondents.

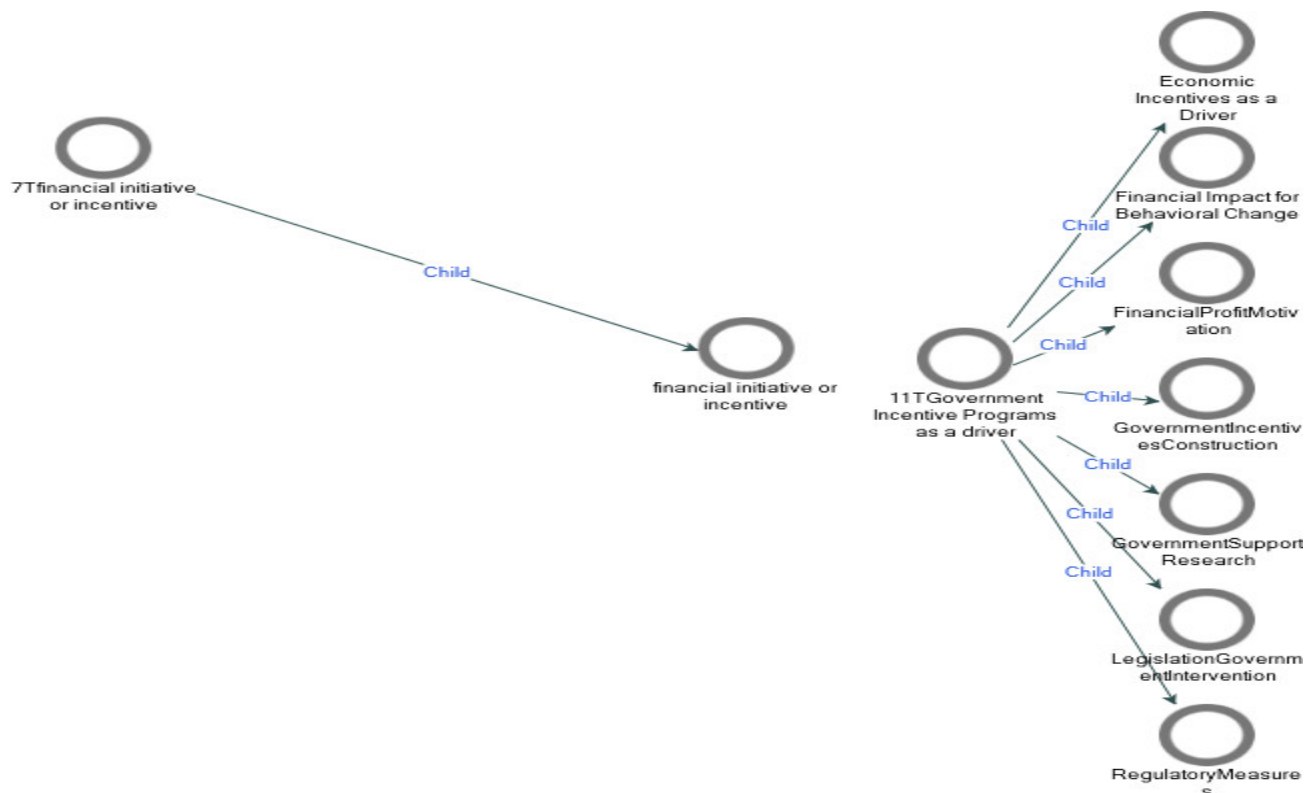


Figure 2. Respondents' views on government incentive programmes as a driver.

4.4. Policy Makers and the Government's Role

Experts emphasize the critical role of government policies and associated sub-themes, such as incentives for promoting green construction techniques, carbon offsetting measures, appropriate land use, community awareness, property owner education, and addressing retrofitting and implementation barriers, as outlined in Figure 1. Construction professionals highlight the importance of legislative and regulatory frameworks in enabling sustainable construction practices. They advocate for stringent construction regulations mandating low-carbon materials and ensuring energy efficiency (see Figure 2). To support performance and safety improvements, respondents advocate for government-backed financial assistance and incentives, as opined by participants P01, P02, P03, P05, and P09.

Fifty per cent of the respondents highlighted the need for financial incentives from the government to drive the implementation of climate change policies. These incentives drive stakeholder behaviour changes and serve as a catalyst for development.

4.5. Results of the Validation Responses

A thematic analysis was conducted to identify key areas of agreement, concerns, and suggestions for improvement. The insights gained were categorised into themes such as the effectiveness of the framework, feasibility, coverage of roles, significant impact components, and potential challenges.

Question 1 (Q1) How effective do you think the framework will be in minimising the impacts of climate change on residential buildings? Six responses opined that the framework is highly effective in minimising the impacts of climate change on the UK residential building. Examples of comments received:

"The framework is highly effective as it addresses critical climate resilience measures."
(Respondent No. 1). Conversely, one opined that:

“Some elements seem blunt and are not as simple as the framework explains. An example of this is the incorporation of sustainability measures into all aspects of new home building, which is not always physically possible. Make the framework more elaborate and detailed, exploring topics not listed and going into further detail regarding some areas, such as planning.”

(Respondent No. 2)

Question 2: Which framework components do you believe will have the most significant impact? Participants highlighted different components of the framework as having the most impact. Two key perspectives stood out:

1. Stakeholder Collaboration and Innovation

“Stakeholder collaboration and adoption of innovative climate-resilient construction techniques.” (Respondent No. 1). This emphasises the importance of collective action and modern construction methods in achieving climate resilience.

2. Policy and Incentives

“I believe the policymakers’ framework will have the most significant impact, as the professionals would have to follow. One of the best is providing an incentive, which would bring professionals a reason to follow this framework.” view underscores the role of policy direction and financial incentives in driving compliance and engagement among professionals.

Question 3: How feasible is it to implement the measures outlined in the framework?

Most respondents agreed that the framework is feasible, provided certain conditions are met—such as financial incentives, collaboration, and time. Respondents highlight the importance of collective commitment across stakeholders for successful implementation. For example,

“I think the framework is feasible to implement if there is buy-in from all roles.”

(Respondent No. 5)

They also reflect concerns about the financial and logistical challenges of retrofitting existing structures. For instance,

“I believe it is not highly feasible as it would be asking developers to revisit existing buildings and would be costly for those involved.”

(Respondent No. 7)

Question 4: Do the roles in the framework cover all the necessary aspects of climate resilience for residential buildings? Yes/No. Four respondents indicated “No”, while three respondents said “Yes,” as shown in Figure 3. The four respondents who said “No” provided additional information, as shown below:

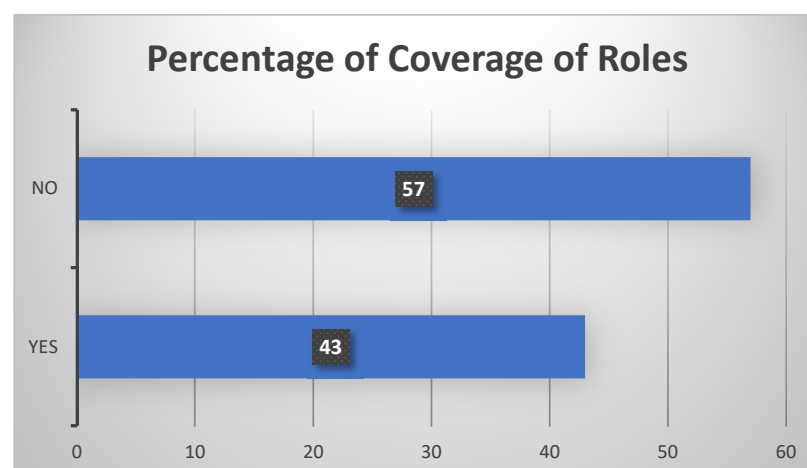


Figure 3. Coverage of roles.

Respondents proposed enhancements to the framework, focusing on clearer guidance for property owners and deeper integration of sustainable practices. Two notable suggestions include: Empowering property owners and sustainable supply chains.

“It seems there is limited information on what property owners can personally do to improve their climate resilience. . . should the roles of individual property owners and the broader community be more clearly distinguished?” (Respondent No. 7). This highlights the need for clearer, actionable guidance tailored to individual property owners.

They emphasise the importance of transparency and sustainability throughout the material sourcing and construction process.

“Building on ‘sustainable’ materials, there should be more emphasis on supply chain as this is a key component of sustainable building. . .”

(Respondent No. 3)

(Q6): Respondents identified several challenges, including resistance to change, funding constraints, and the need for more precise guidance. Two key concerns were: Resistance/awareness and time and industry readiness. For instance,

“Resistance to change, funding limitations, and lack of public awareness.” (Respondent No. 1). This highlights foundational barriers that could hinder widespread adoption and engagement.

They also suggest the practical challenges of aligning industry timelines with policy expectations, emphasising the need for phased implementation and education.

“With any new policies, the construction industry will need time to implement. . . Time and Cost will always be an issue.”

(Respondent No. 6)

(Q7): How well does the framework address the key factors influencing climate resilience in residential buildings? Six respondents believed that the framework addresses the key factors influencing climate resilience in residential buildings, although some suggested that some more factors need to be included.

“The framework comprehensively addresses key climate resilience factors.” (Respondent No. 1). However, respondents opined that.

“I believe there are more key factors to be analysed/introduced during material selection by developers/principal contractors/architects.”

(Respondent No. 4)

(Q8): Respondents offered a range of ideas to enhance the framework, with emphasis on practical examples and clearer stakeholder roles. Two key suggestions include: Real-world case studies and clarifying stakeholder responsibilities.

“Consider integrating more real-world case studies and examples of successful climate-resilient projects.”

(Respondent No. 1)

This highlights the value of practical illustrations to support understanding and inspire confidence in the framework’s effectiveness.

“Should there be legal penalties in place to enforce the mitigation strategies imposed by the policy makers? . . . It may be necessary to distinguish between personal responsibilities and communal roles.”

(Respondent No. 7)

5. Discussion

The study's results reveal a significant positive impact of climate measures and policies on the well-being of occupants in residential buildings ($b = 0.58$, $t = 5.48$, $p < 0.001$), as shown in Tables 3 and 4. These measures and policies strongly predict the residents' overall quality of life. To achieve upcoming energy and climate change objectives, the UK residential sector needs to enhance its performance and efficiency [72]. Furthermore, initiatives focused on upgrading communities with the support of local governments can bolster resilience against climate change threats [73]. Consequently, developing a comprehensive framework to mitigate the effects of climate change could provide guidance to builders, contractors, policy makers, and homeowners regarding the best steps to undertake with respect to the residences in the UK.

There is a growing demand for a shift in policy that encourages more refined upgrading strategies customised to the specific needs of individual buildings and their inhabitants. While promoting high-quality retrofits is advisable, such initiatives should not be motivated solely by profit [74]. The study findings indicate that, contrary to current literature, occupants are primarily concerned about the effects of climate change on their homes rather than the specific measures and policies implemented. Nevertheless, both measures and policies play a critical role in tackling the challenges posed by climate change. Enhancing awareness of climate change's impact on residential properties can facilitate the integration of climate-resilient strategies into the planning and policy-making process, ultimately improving the well-being and safety of building occupants.

The qualitative analysis yielded significant findings, including the necessity of professional construction teams, governments, and individuals/communities working together urgently to improve the resilience of residential buildings. This contrasts with Bichard and Kazmierczak's (2011) findings, where most participants believed flood protection fell under the authority remit and were reluctant to invest in home resilience measures despite available incentives [75]. Onus et al.'s study suggests that overcoming this resistance requires multidimensional approaches, including enhanced communication, collaboration, targeted incentives, and support for vulnerable groups [38].

Furthermore, one of the main barriers that will prevent building professionals from choosing sustainable practices and residents from adapting to climate change is a lack of knowledge about the impending effects of climate change on residential buildings. The American Society of Civil Engineers (ASCE) (2022) suggests that construction professionals must collaborate to revise building codes and standards to ensure climate resilience [76]. Hence, this study found that creating immediate awareness for all stakeholders is key to combating the impacts of climate change on residential buildings. This study highlights various means of disseminating climate information to all stakeholders in the UK, such as education, training, conferences, media, and curriculum change involvement. The study also emphasises the importance of incentives for homeowners to prepare for the effects of climate change, as well as a critical area for immediate implementation. Globally, governments offer subsidies and incentives to promote economic expansion and lessen socioeconomic disparity [77].

Moreover, ignorance, human and building factors, poor policy implementation, and a lack of incentives are significant barriers to increasing residential building resilience. This study also included research on actions that should be taken to address the effects of climate change on residential buildings in the United Kingdom. Resilience in UK residential buildings can be increased through measures, incentives, technology-related factors, education, and information. The results are to create a framework highlighting the interactions between stakeholder inputs and help minimise climate change's impacts on UK residential buildings.

5.1. A Framework of Measures to Minimise the Impacts of Climate Change on UK Residential Buildings

A framework is a structured approach or guidelines to address a specific problem or task. It is a structured way to organise and approach a study. A framework can include elements from theories and models but also focus on practical application. Frameworks are less abstract than theories and often serve as a guide for research design and methodology [78]. Frameworks provide a systematic way to organise and analyse information, often used in research, project management, and policy development. They guide the study design, data collection, and analysis, helping to ensure consistency and rigour in methodology. Frameworks can also provide context for interpreting results [71]. However, frameworks are helpful for communication since they tend to organise, explain, or describe information as well as the variety and relationships between concepts, including some that outline processes [79].

5.2. Type of Framework Adopted

To reduce climate change impacts on UK residential buildings, a collaborative framework involving construction experts, policy makers, and communities is required. This integrated strategy targets multiple challenges, including physical damage, inefficient energy use, occupant discomfort, and a lack of resilience.

A conceptual framework defines foundational ideas, clarifying relationships and guiding the study's logic [79]. A theoretical framework draws from established theories, offering an interpretative lens and embedding the research within scholarly discourse [79]. The analytical framework focuses on the tools and methods used to evaluate data systematically [80].

This study adopts a determinant framework, which explores influencing factors that affect implementation outcomes [81]. Emphasis lies on the characteristics of these frameworks, which shape how findings are applied. Determinant frameworks are particularly well-suited to evaluating the interaction between influencers and outcomes, surpassing the limitations of using models or theories alone.

Moullin et al. (2020) argue that implementation initiatives should be preceded by a structured implementation framework [79]. According to Moullin et al. (2020), such frameworks are supported by mediators and practitioners to facilitate planning, execution, and assessment in real-world contexts, providing a shared vocabulary to engage stakeholders [80]. Implementation frameworks can be categorised into three types: (1) process frameworks, which guide the rollout of interventions; (2) determinant frameworks, which identify influencing factors; and (3) outcome frameworks, which assess the results [81,82].

The integration of implementation and determinant frameworks promotes flexibility and adaptability, allowing adjustments when new challenges or enablers are identified. This combined approach enhances the sustainable application of evidence-based practices, strengthening the likelihood of achieving long-term climate resilience in residential buildings.

This underscores the need for clearer definitions of roles and accountability among property owners, tenants, and other stakeholders. Figure 4 shows a framework of measures to minimise the impacts of climate change on UK residential buildings.

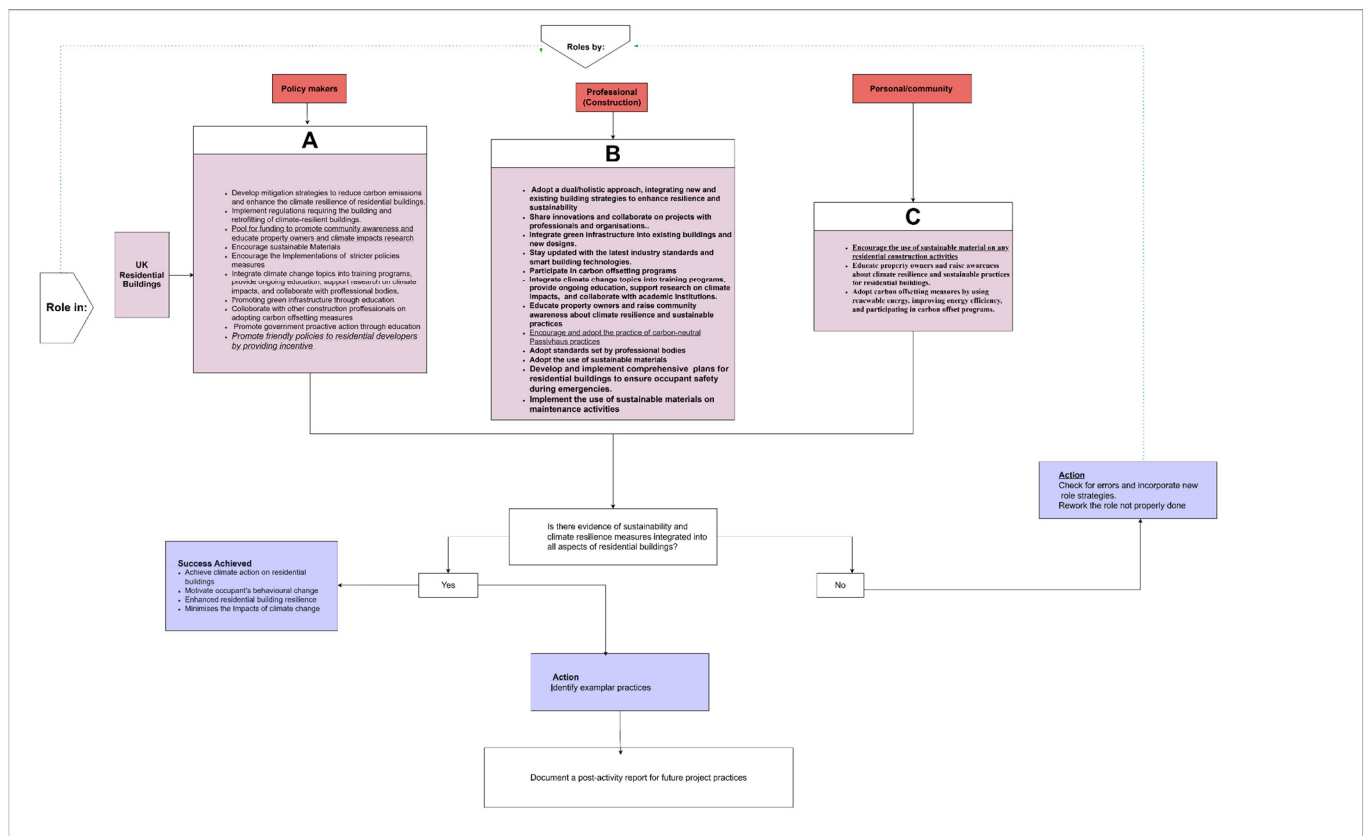


Figure 4. Framework of measures to minimise the impacts of climate change on UK residential buildings.

5.3. Benefits of the Proposed Framework

The proposed framework will enhance climate resilience in the UK residential building sector by:

- Aiding construction professionals, policy makers, and stakeholders by enhancing informed decision-making and encouraging the spread of climate-related information in the residential sector.
- Allowing the government to make informed decisions about trade-offs between long- and short-term priorities, investment, or funding allocation of priority areas.
- Contributing to the formulation of robust mitigation and adaptation strategies tailored to residential buildings, ensuring alignment with national climate objectives.
- Serving as a valuable tool for policy makers, helping them identify areas of concern for residents that require immediate attention.
- Helping policy makers ensure alerts reach at-risk individual homes in good time.
- Informing the construction sector about adopting management plans to enhance the resilience of residential buildings against the impacts of climate change.

6. Conclusions and Recommendations for Future Work and for Industry

This study contributes to our understanding of the impacts of climate change on residential buildings in the UK. It provides valuable empirical data that is essential for addressing this pressing issue. The study's pragmatic approach highlights the practicality, flexibility, and adaptability involved in such research but also underscores its real-world applications. Here are the recommendations from this study:

- The construction team's involvement in designing efficient residential buildings is crucial to achieving resilience efficiency in the building subsector. Therefore, it is

imperative to prioritise their participation in the building development process to enhance buildings' ability to withstand the effects of climate change.

- Construction professionals are not just participants but leaders in the fight against climate change. Their expertise and innovation are crucial. Hence, the school curriculum should incorporate the relevance of climate change into every course, empowering the next generation to continue this essential work.
- The government's role in offering financial incentives through suitable policies is crucial. 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.

7. Limitations of the Study

This study's data were sourced solely from the UK, which may limit broader applicability to other regions due to differing climatic and socioeconomic conditions. Furthermore, the absence of specific instruments for assessing climate impacts on building components restricted detailed evaluation of individual building envelope elements. Reliance on self-reported survey data introduces potential bias, although this was partially mitigated through triangulation with qualitative interviews.

For enhanced accuracy, future research should incorporate real-time monitoring of building performance during extreme weather events. Additionally, while the developed framework is tailored to the UK context, its adaptability to other geographic settings remains untested. Future studies are encouraged to contextualise and refine the framework for different climates and socioeconomic environments to determine its international relevance.

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Informed Consent Statement: To ensure confidentiality and anonymity, all interviewees signed consent forms prior to the interview. Prior to the quantitative phase, involvement in follow-up questions required acceptance of informed consent. Anonymity was guaranteed, and participation occurred only with consent, which included a non-disclosure agreement. Data management practices at the University of Wolverhampton ensured secure handling, storage, and disposal of research data, effectively maintaining participant confidentiality and anonymity. Research data, stored on password-protected portable external hard drives, was safeguarded against unauthorised access.

Data Availability Statement: The corresponding author may provide the anonymous data from this study upon request.

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