**Assessing Climatic Risks on Commercial Real Estate in Ayeduase and Kotei, Ghana: Pathways to a Sustainable Future**

**ABSTRACT**

The paper evaluated the effects of climate change, particularly temperature increases, on commercial real estate in Ayeduase and Kotei, Ghana. The research identified rising temperatures as a significant risk affecting property values, operational efficiency, and sustainability. It aimed to explore stakeholder perceptions, assess climate risks, and propose adaptation strategies for the commercial real estate sector. A qualitative research approach involved 20 stakeholder interviews and document analysis. Participants included property developers, investors, real estate agents, government officials, and environmental experts, who provided insights into increased temperatures' financial and structural implications. The findings indicated that primary concerns included higher cooling costs, infrastructure deterioration, and reduced tenant satisfaction. The demand for cooling systems surged, resulting in increased operational expenses. Structural vulnerabilities, such as material degradation, were noted due to prolonged exposure to extreme heat. The study found that while some stakeholders had implemented energy-efficient cooling technologies and climate-responsive building designs, financial limitations and a lack of awareness hindered broader adaptation efforts. It recommended policy measures such as stricter building regulations, financial incentives for green construction, and investments in sustainable urban planning. Additionally, it emphasized the need for greater stakeholder awareness and collaboration between the government and private sector to enhance climate resilience. A key limitation of the study is its relatively small sample size, which may not capture the full diversity of stakeholder perspectives. However, the findings provide valuable insights for future research. Future research should investigate the long-term financial impacts of climate risks on commercial real estate and evaluate the effectiveness of adaptation strategies over time. The study concluded that integrating climate-responsive strategies into real estate development is vital for ensuring sustainable urban growth and mitigating the risks associated with climate change.

**Keywords:** Climatic Risk, Commercial Real Estate, Temperature Rise, Sustainability, Climate Adaptation.

**1.0 INTRODUCTION**

Real estate is critical for global economic development, providing infrastructure for various activities. However, the sector faces challenges from climate change, which threatens property values, infrastructure resilience, and sustainability due to increased extreme weather events, rising temperatures, and changing precipitation patterns (Baldauf, Garlappi & Yannelis, 2020). Human activities, such as fossil fuel combustion and deforestation, drive these changes, leading to greenhouse gas emissions that disrupt global climate patterns (Thomas, Rachael, & Cameron, 2020). Rising temperatures result in extreme heat, higher energy demand, and risks to property durability and value (Dosio, Mentaschi, Fischer, & Wyser, 2018). In Sub-Saharan Africa, the impacts of climate change on real estate are increasingly visible, with rising temperatures, prolonged droughts, and extreme weather affecting urban infrastructure and investments. Metropolitan areas are particularly vulnerable due to the urban heat island effect, which exacerbates temperature increases and energy consumption (Muldoon-Smith & Greenhalgh, 2019). Climate adaptation strategies like green building designs and improved land-use planning are being explored to enhance resilience and sustainability (Talinbe & Baffour-Awuah, 2021).

In Ghana, rapid urbanization alongside climate change poses significant risks to the real estate sector. Rising temperatures and shifting precipitation threaten the sustainability of commercial and residential developments (Mohammed, Batung, & Luginaah, 2021). The socio-economic implications in urban centers are substantial, affecting productivity and public health. Despite initiatives to promote climate resilience in urban planning, significant gaps remain in addressing temperature rise risks in specific locations.

The rapid development of cities in Ghana has heightened vulnerability to climate risks, particularly rising temperatures. As key commercial and residential hubs, they have experienced significant urban expansion, leading to intensified Urban Heat Island (UHI) effects due to increased construction and reduced vegetation. This situation impacts real estate functionality and sustainability. Despite the pressing challenges posed by climate change, including increased energy costs and reduced indoor comfort, there is a lack of empirical research focusing specifically on the consequences of temperature rise on commercial real estate in these regions (Murfin & Spiegel, 2020).

Ghana’s rapid urbanization drives commercial real estate growth while increasing climate risks. Amoako & Frimpong Boamah (2020) examine Ghana’s urban resilience in the context of flood vulnerability, highlighting the broader need for integrated climate adaptation strategies in urban planning. This is informed by a case study of a residential neighbourhood of Kumasi, the second largest city in Ghana. By examining climatic risks, stakeholder perceptions, and adaptation strategies, the research seeks to provide valuable insights for enhancing real estate resilience in Ghana. The research objectives therein pursued are as follows: (i) to examine stakeholder perceptions of temperature rise as a climatic risk in commercial real estate in Ayeduase and Kotei, Ghana; (ii) to assess the current and projected climate risks faced by the commercial real estate sector in Ayeduase and Kotei, Ghana; and, (iii) to identify and evaluate strategies for enhancing resilience and sustainability within the Ghanaian real estate sector.

**2.0 LITERATURE REVIEW**

Climate change poses significant challenges to commercial real estate, particularly in urban areas. This paper examines the implications of rising temperatures and extreme weather events, reviewing existing literature on climatic risks essential for developing sustainable real estate strategies. Climatic risks are defined and categorized into three main types: physical risks, which are direct impacts from extreme weather (Zifeng, Lu-Andrews, & Zhonghua, 2022); transition risks, arising from regulatory changes and shifting consumer preferences, impacting market viability (Sarah, Jim, Steven, & Jorn, 2022); and liability risks, which involve legal repercussions from climate-related damages. It also incorporates empirical studies that identify vulnerabilities in similar regions and discusses theoretical perspectives from urban planning and environmental science to enhance understanding of climate risk management in urban settings. Addressing these risks is crucial for protecting cash flow and property valuations (Sarah, Jim, Steven, & Jorn, 2022).

**2.2 Factors Contributing to Climatic Risk**

***Temperature Rise:*** Global warming driven primarily by anthropogenic activities like greenhouse gas emissions (Mattheos, 2020) influences factors contributing to climatic risks in commercial real estate, such as temperature rise, significantly. This phenomenon has profound implications for commercial properties (Tanya, et al., 2021), where the impacts of rising temperatures are becoming increasingly evident. Heatwaves, exacerbated by climate change, place significant stress on building infrastructure, particularly HVAC systems, resulting in heightened energy consumption and operational costs (Wisdom, et al., 2024). Elevated temperatures can decrease occupant comfort and productivity, prompting the adoption of adaptive measures such as enhanced insulation and energy-efficient cooling technologies to maintain indoor environments conducive to productivity and well-being. Understanding and addressing these thermal challenges through climate-responsive design strategies are critical for fostering sustainable development practices in the local real estate sector.

***Extreme Weather Events*:** Commercial real estate faces considerable vulnerability to a variety of extreme weather events, including hurricanes, floods, wildfires, and storms (Georgia & Anna, 2022). These events directly jeopardize property integrity and functionality. Hurricanes, for instance, can cause structural damage and flooding, disrupting business operations and necessitating costly repairs (Jawad, Eva, & Erkan, 2024). Flood risks are compounded by shifting precipitation patterns and inadequate drainage systems, particularly affecting properties situated in low-lying areas. In regions prone to prolonged droughts and heatwaves, wildfires pose a significant threat, especially to properties near forested areas or susceptible to wildfire outbreaks (Rogier, Dongxiao, & Siqi, 2023). Effective risk management entails proactive measures such as implementing resilient building designs, improving disaster preparedness plans, and natural hazard assessments into property development and management protocols. These strategies are critical for enhancing the resilience of commercial real estate against the escalating impacts of climate change.

**Changing Precipitation Patterns:** Altered rainfall patterns, another consequence of climate change, contribute to climatic risks in commercial real estate. Increased intensity and frequency of rainfall events can overwhelm drainage systems, leading to urban flooding and water damage to properties (Shamsuddin, et al., 2017). Conversely, prolonged periods of drought can strain water resources, influencing landscaping and irrigation practices essential for maintaining aesthetic appeal and property value. Real estate developers and managers in regions like Kotei and Ayeduase must anticipate these precipitation-related challenges and adopt sustainable water management strategies. These may include incorporating rainwater harvesting systems, designing permeable surfaces to mitigate runoff, and promoting water-efficient landscaping practices. Understanding the factors that contribute to climatic risks in the 13 commercial real estate is critical for stakeholders. Addressing issues such as temperature rise, extreme weather events, and changing precipitation patterns through proactive risk management and sustainable development practices can significantly enhance the resilience and long-term viability of commercial real estate assets in climate change. By adopting strategies to mitigate these risks, stakeholders can safeguard properties against potential damages and operational disruptions caused by environmental shifts. This proactive approach not only protects investments but also fosters sustainable development, ensuring that commercial real estate remains adaptive and resilient amid evolving climatic challenges.

**2.3 Theoretical Review**

Understanding the impact of climate risks on commercial real estate requires a strong theoretical foundation. Various urban planning and resilience theories provide insights into how real estate developments can adapt to climate change and mitigate associated risks. These theories help in identifying strategies for sustainable urban planning, climate adaptation, and resilience-building within commercial real estate. This section explores key urban planning theories and resilience theory, examining their relevance to climate risk management in the context of Ayeduase and Kotei.

***Urban Planning Theories:*** Urban planning theories play a crucial role in mitigating climate risks within real estate. The compact city theory, as described by Michele and Harriet (2021), advocates for dense mixed-use development, which reduces carbon emissions and enhances sustainable transportation, thereby addressing urban heat island effects (Pal & Gopal, 2023). New Urbanism emphasizes walkable neighborhoods, green spaces, and efficient land use to improve climate resilience and community well-being (Carmona, 2021). These frameworks guide urban design strategies that implement nature-based solutions, green infrastructure, and adaptive building designs to combat climate risks and enhance the resilience of commercial properties. The strategic interventions align urban planning with climate adaptation goals, fostering sustainable development. The hazard-vulnerability-capacity framework serves as a tool to evaluate urban areas' exposure to climate hazards and assess the vulnerability of both built assets and populations while measuring adaptive capacity (Joakim & Oulahen, 2021). Scenario planning models can simulate future climate scenarios and their impacts on real estate portfolios, enabling proactive risk management (Rutting, Vervoort, Mees, & Driessen, 2021). These models aid stakeholders in Kotei and Ayeduase in pinpointing vulnerability hotspots, prioritizing adaptation measures, and optimizing resource allocation to strengthen climate resilience. By integrating these theoretical perspectives and models, stakeholders can create innovative strategies to address climate risks, foster sustainable urban development, and bolster the resilience of commercial properties amidst climate change challenges.

***Resilience Theory:*** Selecting an appropriate theoretical framework is crucial for assessing climatic risks in commercial real estate. This study integrates resilience theory to explore how socio-ecological systems adapt to and thrive amidst environmental stressors (Adie, 2020). Resilience theory underscores the capacity of systems to absorb disturbances and reorganize, making it relevant for understanding and enhancing resilience against climate risks (Adie, 2020). It asserts that socio-ecological systems possess adaptive capacities that can help navigate environmental challenges. For commercial real estate, this theory emphasizes the need for flexibility and adaptability in development strategies to withstand climate-related disruptions and promote long-term sustainability (Adie, 2020).

The study focuses on applying resilience theory to urban real estate, aiming to identify strategies that increase adaptive capacity and decrease vulnerability to climate threats. By examining stakeholders' perceptions and decision-making processes, it seeks to provide insights into effective resilience-building measures. Overall, the framework aims to illustrate how resilience theory can inform practical strategies for improving climate resilience in commercial real estate, guiding policy and urban planning in changing environments.

**2.4 Conceptual Framework**

This conceptual framework visualizes how temperature rise, as a key climatic risk, affects commercial real estate in Ayeduase and Kotei. The framework follows a logical flow, outlining the direct impacts, mediating and moderating factors, and potential solutions leading to sustainability. It reflects the key components influencing commercial real estate in the context of rising temperatures: (1) Climate Change and Temperature Rise, (2) Direct Impacts on Commercial Real Estate, (3) Moderating & Mediating Factors, (4) Sustainable Real Estate Future (Outcome).

***Climate Change and Temperature Rise:*** Climate change, particularly temperature rise, is the central environmental challenge influencing commercial real estate. The increase in temperature leads to multiple risks, including heat stress on buildings, increased energy demand, and changing tenant behaviors.

***Direct Impacts on Commercial Real Estate:***The physical impact of rising temperatures on commercial buildings includes accelerated deterioration of structures, leading to weakened building integrity over time. Additionally, higher temperatures increase the need for cooling systems, thereby raising energy consumption and operational costs.

The economic impact is seen in fluctuating property values and rental prices, as buildings that are not climate-resilient may face declining demand. Operating expenses increase due to higher maintenance and cooling costs, which can discourage investment in affected areas.

The social and behavioral impact includes shifts in tenant preferences, where businesses and residents may relocate to areas with better climate adaptation measures. Investor confidence may decline if properties in Ayeduase and Kotei are perceived as vulnerable to climate risks, affecting market stability.

***Moderating & Mediating Factors:*** Urban planning and policies play a crucial role in shaping the resilience of commercial real estate to temperature rise. The presence of green spaces, climate-conscious city planning, and regulations promoting sustainable development can mitigate the adverse effects of rising temperatures. Government interventions such as zoning laws, tax incentives, and stricter building codes for energy efficiency further enhance real estate sustainability. Adaptation strategies also influence the degree of impact. The use of energy-efficient materials, green roofing, and improved ventilation systems can help mitigate the effects of rising temperatures. Climate-resilient designs and sustainable construction techniques, including the integration of smart building technologies, provide long-term solutions to maintaining commercial property value and functionality.

***Sustainable Real Estate Future (Outcome):*** If the right policies, infrastructure improvements, and adaptation strategies are effectively implemented, commercial real estate in Ayeduase and Kotei can become more resilient to climate risks. Sustainable real estate practices, such as obtaining green building certifications and adopting smart energy management systems, will ensure long-term investment stability and environmental sustainability. The transition towards climate-adaptive real estate development will not only protect existing investments but also attract future investors, fostering a more robust and sustainable urban economy.

This conceptual framework establishes a structured pathway to understanding the relationship between temperature rise and commercial real estate, emphasizing the importance of policy interventions and adaptive strategies in securing a sustainable

**Climate Change: Temperature Rise**

**Economic Impact**

Property Values, Rental prices, Operating Expenses

**Social and Behavioral Impact**

Tenant preferences, occupancy rates, investor confidence)

**Physical Impact**

Building Deterioration, Cooling Costs, structural integrity.

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**Adaptation Strategies**

Energy-Efficient building, Climate-resilient designs

**Moderating & Mediating Factors**

Urban Planning, Policies, Green Spaces, Incentives

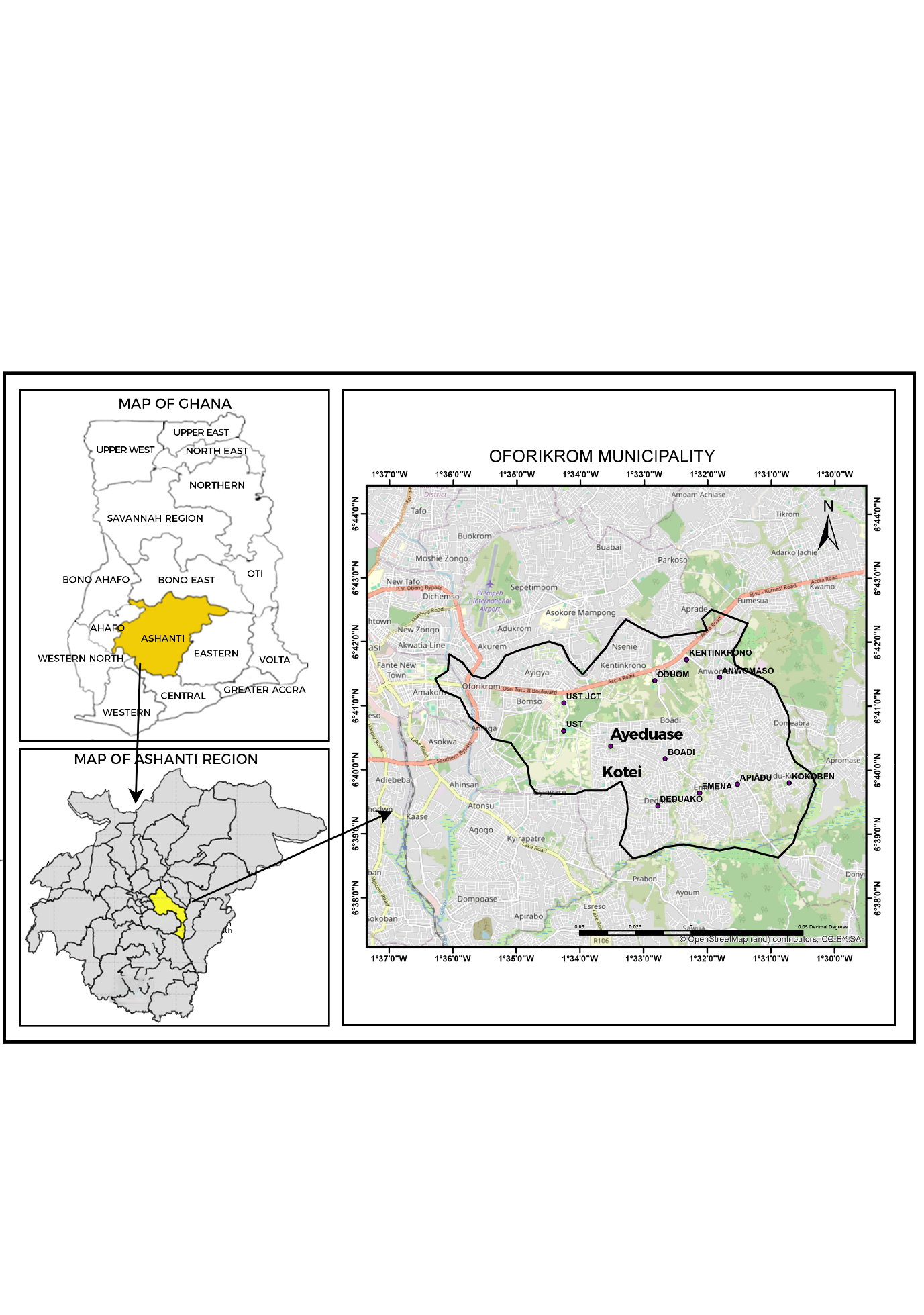
**Enhanced Resilience**

**Sustainable Real Estate Future (Outcome)**

**Figure 1:** Conceptual Framework of Climate Risk on Commercial Real Estate. Source: Authors’ Construct

**3.0 Research Methodology**

The methodology employed in the study includes the description of the study area, research design, target population, sampling techniques, data collection methods, data analysis, and ethical considerations. The paper sought to assess climatic risks in commercial real estate within Kotei and Ayeduase, focusing on rising temperatures and their financial implications for stakeholders in the sector. Kotei and Ayeduase are two rapidly growing urban areas in Kumasi, the second-largest city in Ghana. These locations were selected due to their increasing exposure to climate risks, particularly rising temperatures, which have the potential to significantly impact commercial real estate development and operations. Ayeduase and Kotei are characterized by rapid urbanization, increasing commercial real estate activities, and growing concerns about climate change impacts, making them suitable for assessing how rising temperatures affect real estate investments and management. The area of study experiences a tropical climate characterized by distinct rainy and dry seasons, with recent temperature trends showing a steady increase from 26.8°C in 2010 to 33.0°C in 2022.



**Figure 2:** Map of Kumasi showing Oforikrom Municipality. Source: Authors’ Construct.

Figure 3: Temperature Trends in Ayeduase and Kotei (2010-2022)Source: Climate Finance Adaptation Study Report, Civic Response, (2022) Ghana.

A qualitative research design was adopted to explore stakeholders' perceptions of financial risks and adaptation strategies in commercial real estate. The study employed thematic analysis to examine data obtained from interviews and document analysis, ensuring an in-depth understanding of climate risks and financial liabilities associated with temperature increases. The target population comprised key stakeholders in the commercial real estate sector, including property developers, investors, real estate agents, local government officials, and environmental experts. A purposive sampling technique selected 20 participants, ensuring diverse perspectives on climate risks and real estate investments. A total of 20 respondents participated in the study, including 5 property developers, 4 investors, 3 real estate agents, 4 local government officials, and 4 environmental experts.

Data was collected through primary and secondary sources. Primary data involved semi-structured interviews conducted with selected stakeholders to gather insights into their experiences, perceptions, and strategies for managing climatic risks in commercial real estate. Secondary data consisted of document analysis performed on reports, policy documents, and academic literature related to climate risks and real estate sustainability. Thematic analysis was used to analyze qualitative data, employing NVivo 12 software to identify patterns and themes related to climatic risks in commercial real estate. The analysis focused on financial impacts such as increased maintenance costs, insurance premiums, and operational adjustments due to rising temperatures. Ethical considerations were strictly observed to ensure research integrity and participant confidentiality. Informed consent was obtained from all respondents before data collection, and the collected data were anonymized to protect participants' identities. Additionally, the study adhered to ethical guidelines for qualitative research, ensuring transparency and credibility in data collection and analysis. This methodology framework provided a structured approach to understanding climatic risks and their implications for commercial real estate in Kotei and Ayeduase, facilitating evidence-based recommendations for enhancing resilience in the sector. However, as the study relies on qualitative data from stakeholder perceptions, potential subjectivity in responses is acknowledged as a limitation. To mitigate bias, thematic analysis was conducted using NVivo 12, ensuring analytical rigor and consistency in identifying patterns and themes.

**4.0 Result and Discussion**

**4.1 Demographic Characteristics**

The demographic characteristics of respondents provide insights into their perspectives on climatic risk in commercial real estate in Kotei and Ayeduase. These details help contextualize the data collected. The gender distribution indicates that 60% of respondents are male, while 40% are female. This may reflect the composition of professionals in the commercial real estate sector. Gender influences perceptions of climate change, with male participants often dominating decision-making, while female stakeholders may focus on social impacts and community-oriented adaptation strategies. Regarding age, 35% of respondents are between 26 and 35 years, followed by 25% in the 36-45 age group. Those under 25 years make up 20%, while 15% fall within the 46-55 age bracket, and 5% are above 56 years. Younger professionals may be more aware of climate change due to global sustainability efforts, whereas older respondents bring long-term perspectives on real estate sector adaptations to climatic risks. Educational qualifications further shape climate risk perceptions. The majority (45%) hold a Bachelor’s degree, 20% have postgraduate education, 20% possess a Diploma or HND, 10% completed WASSCE/SSCE, and 5% have vocational or technical certificates. Higher education correlates with awareness of climate resilience frameworks and sustainability concepts, influencing responses to adaptation measures. These demographic insights ensure diverse perspectives on the impact of rising temperatures on commercial real estate, strengthening the study’s recommendations on climate resilience strategies.

## 4.2 Analysis of Survey Data

***Awareness and Perception of Climate Change***

**Table 1: Analysis of the Responses to Awareness and Perception of Climate Change**

|  |  |  |
| --- | --- | --- |
| **THEME** | **SUB-THEME** | **RELEVANT REPONSES** |
| **Definition of Climate Change** | -Long-term atmospheric changes  -Human activities as primary causes | Climate change involves long-term temperature and atmospheric changes due to human activities. |
| **Awareness of Climatic Risks** | -High awareness of impacts  -Moderate awareness  -Limited knowledge | Respondents exhibit a range of awareness, most recognizing significant risks, while a few have limited knowledge. |
| **Information Sources** | -Industry reports  -Online news  -Government publications  -Academic journals  Social media | Most rely on industry reports and online news; some use government publications and academic journals, with few using social media. |
| **Changes in Weather Patterns** | -Increased temperatures  -Irregular rainfall  -More extreme weather events | Observations include rising temperatures, irregular rainfall, and increased frequency of extreme weather events. |
| **Primary Climate-related Risks** | -Increased cooling costs  -Damage from extreme weather  -Changing precipitation  -Health risks | Key risks identified are higher cooling costs, damage from storms  and floods, impacts on  infrastructure, and health concerns. |

Source: Field Survey October, 2024

The impact of changing precipitation patterns, a consequence of climate change, poses significant risks for commercial real estate. Increased rainfall intensity can overwhelm drainage systems, leading to urban flooding and property damage, while prolonged droughts strain water resources, affecting landscaping and irrigation and ultimately property value (Shamsuddin et al., 2017). Stakeholders in regions like Kotei and Ayeduase need to anticipate these challenges and implement sustainable water management strategies, such as rainwater harvesting and permeable surfaces. Proactive risk management and sustainable development can enhance the resilience and viability of commercial real estate assets in the face of climate change.

A comparative analysis of similar urban areas facing climate challenges provides further insight into these risks. Lagos, Nigeria, experiences significant urban flooding and extreme heat, which negatively impact commercial real estate investments (Oladokun, 2016). Research indicates that excessive heat exposure results in increased cooling costs, accelerated infrastructure deterioration, and lower tenant retention rates, mirroring the concerns identified in Kotei and Ayeduase. Adaptation measures in Lagos, such as improved drainage systems, climate-resilient building designs, and government incentives for sustainable construction, offer valuable lessons for addressing climate risks in Ghana's real estate sector (Nairametrics, 2024).

The theoretical framework for understanding climate risks in commercial real estate encompasses various urban planning and resilience theories. Urban planning theories, such as compact city theory (Michele & Harriet, 2021) and New Urbanism (Carmona, 2021), advocate for dense, mixed-use developments and walkable neighborhoods to mitigate climate risks. The hazard-vulnerability-capacity framework (Joakim & Oulahen, 2021) aids in assessing urban areas' vulnerability to climate hazards, while scenario planning models (Rutting et al., 2021) assist stakeholders in identifying vulnerability hotspots and prioritizing adaptive measures.

Resilience theory (Adie, 2020) highlights systems' capacity to absorb disturbances and adapt to environmental stressors, making it essential for developing strategies to enhance resilience in commercial real estate. This study aims to apply these theoretical frameworks to identify and promote effective resilience-building measures among stakeholders, contributing to sustainable urban development in climate change.

***Impact of Temperature Rise***

**Table 2: Analysis of the Responses on Impact of Temperature Rise**

|  |  |  |
| --- | --- | --- |
| **THEME** | **SUB-THEME** | **RELEVANT REPONSES** |
| **Impact of Temperature**  **Rise** | -Increased cooling costs  -Property damage  -Operational inefficiencies  -Tenant discomfort | Temperature rise leads to higher cooling costs, potential damage to  property structures, and  operational inefficiencies. Tenant comfort and property appeal are also affected. |
| **Examples of Temperature**  **Impact** | -Increased energy bills  -Damage to building exteriors  -Uncomfortable indoor temperatures | Specific incidents include rising energy bills due to increased use of air conditioning, damage to building exteriors like cracks and fading paint, and uncomfortable temperatures in office spaces. |
| **Significant Challenges** | -Expensive HVAC upgrades  -Increased maintenance costs  -Reduced property durability  -Tenant dissatisfaction | Major challenges include the high cost of upgrading HVAC systems, increased maintenance expenses, reduced property durability, and potential tenant dissatisfaction. |
| **Influence on Property Values** | -Decreased property values  -Higher operational costs  -Impact of outdated cooling systems | Temperature rise is perceived to decrease property values due to increased operational costs and potential damage, especially affecting properties with outdated cooling systems. |
| **Operational Challenges** | -Increased the consumption  -Frequent HVAC maintenance  -Ensuring tenant comfort | Operational challenges include managing higher energy consumption, frequent HVAC maintenance, and ensuring tenant  comfort despite rising  temperatures. |

Source: Field Survey October, 2024

The impact of rising temperatures on commercial real estate is perceived as significant and multifaceted, leading to higher cooling costs, structural vulnerabilities, and operational inefficiencies (Lawrence, Blackett, & Cradock-Henry, 2020). Respondents reported increased energy bills due to prolonged use of air conditioning, visible damage to building exteriors, and uncomfortable indoor conditions, corroborating findings from Moses and Divine (2020). These challenges indicate the urgent need for enhanced climate resilience strategies, as operational issues can escalate maintenance costs and reduce building lifespans (Majid & Kaan, 2020). High costs associated with upgrading HVAC systems pose significant challenges, as older units often fail to meet the increased demand, resulting in tenant dissatisfaction (Malka & Nishani, 2019). Respondents expressed concern about the financial burden of repairs and the long-term impact on tenant retention and property values. Inadequate adaptation to climate risks can lead to the “stranding” of real estate assets, resulting in diminished market value (Mark et al., 2020).

The operational challenges include increased energy consumption and frequent HVAC failures, highlighting the necessity for climate-resilient designs in commercial buildings (Mhosen & Sami, 2020). Respondents advocate for investment in adaptive management strategies and energy-efficient technologies to ensure property functionality and tenant satisfaction. As Meagher (2020) emphasizes, addressing these operational and structural challenges is crucial for the long-term viability of commercial real estate, particularly in regions like Kotei and Ayeduase.

***Adaptation Strategies***

**Table 3: Analysis of the Responses to Adaptation Strategies**

|  |  |  |
| --- | --- | --- |
| **THEME** | **SUB-THEME** | **RELEVANT RESPONSES** |
| **Current Adaptation Measures** | -Upgrading HVAC systems  -Energy-efficient technologies  -Enhanced insulation  -Green roofs and reflective materials | Strategies include upgrading HVAC systems, installing energy-efficient technologies, improving building insulation, and using green roofs and reflective materials. |
| **Effectiveness of Strategies** | -Effective in reducing costs  -Varied implementation success  -Insufficient measures | Some strategies are effective in reducing cooling costs and  improving energy efficiency, but effectiveness varies based on implementation and maintenance. |
| **Successful**  **Examples** | -Energy-efficient HVAC systems  -Green roofs  -Reflective building materials | Examples include energy-efficient HVAC systems leading to lower cooling costs, and green roofs mitigating heat absorption and improving insulation. |
| **Reason for Adoption or Non-Adoption** | -Regulatory requirements  -Cost savings  -Increased property value  -High initial costs  -Lack of awareness  -Low perceived return on investment | Adoption reasons include regulatory compliance, cost savings, and property value increase. Non-adoption reasons include high initial costs, lack of awareness, and perceived low ROI. |
| **Investment Prioritization** | -Immediate financial impact  -Regulatory compliance  -Long-term value  -Budget constraints | Climate resilience investments are prioritized based on immediate financial impact, regulatory requirements, and long-term value, but some prioritize other needs due to budget constraints. |

Source: Field Survey October, 2024

As shown in Table 3, respondents discussed various adaptation strategies aimed at mitigating climatic risks in the commercial real estate sector. The key measures identified include upgrading HVAC systems, implementing energy-efficient technologies, enhancing building insulation, and incorporating green roofs and reflective materials. These strategies align with broader global efforts to address the impacts of climate change on infrastructure. Hans, Dennis, Sven, and Julia (2020) emphasize the importance of such adaptive interventions in managing climate risks across global real estate markets.

Improving energy efficiency and reducing the burden on cooling systems are crucial for tackling the increasing challenges posed by rising temperatures and other climate-related threats. Respondents reported mixed results regarding the effectiveness of these adaptation strategies. Some noted significant benefits, such as reduced cooling costs and improved energy efficiency, particularly after installing advanced HVAC systems and green roofs. These measures have successfully enhanced building insulation and mitigated heat absorption, leading to a more sustainable and cost-effective approach to property management.

This observation aligns with the findings of Jawad, Eva, and Erkan (2024), who reported similar benefits in regions impacted by extreme weather events, such as Hurricane Sandy, where resilience investments proved effective in climate adaptation strategies in commercial real estate has led to notable cost reductions and sustainability improvements, although challenges remain. Issues such as poor maintenance and lack of planning, highlighted by Irene (2020), can hinder effectiveness. Additionally, limited awareness among property managers restricts potential benefits. Successful adaptations, like energy-efficient HVAC systems and green roofs, enhance energy savings and temperature regulation.

Economic incentives, particularly cost savings and increased property values, drive adoption, aligning with Jussi's (2020) emphasis on financial motivations. However, barriers like high initial costs and perceived low returns deter investment, echoing Hinkel et al. (2018). Regulatory compliance is also a key motivator, with policies mandating resilience strategies, but less stringent regulations can reduce prioritization. Investment decisions rely on immediate financial impacts and long-term property value, reflecting the complexities noted by Jacob (2021). Similar findings are observed in other sectors, such as Tanzania’s agro-pastoral systems, where localized climate adaptation strategies have proven effective in balancing costs and resilience benefits (Sewando, 2024). This underscores the importance of context-specific adaptation approaches in commercial real estate, where financial incentives, policy frameworks, and awareness propel climate resilience investments. Overall, the increasing recognition of climate risks suggests that resilience is becoming vital for the future of commercial real estate. Effective strategies depend on aligning financial incentives, regulatory frameworks, and stakeholder awareness to promote sustainable development in the face of climate challenges.

***Stakeholder Perceptions***

**Table 4: Analysis of the Responses on Stakeholder Perceptions**

|  |  |
| --- | --- |
| **THEME** | **SUB-THEME** |
| **Stakeholder Perception of Climate Change Risk** | -Operational inefficiencies associated with weather variability  -Long-term impact on property values.  -Infrastructure degradation due to temperature fluctuations. |
| **Decision Making factors in Climate Change Adaptation** | -Cost concerns as the dominant decision-making factor.  -Regulatory pressures.  Public and tenant demand for green initiatives. |
| **Climate Change Resilience Promotion in Commercial**  **Real Estate** | -Private sector leadership in implementation.  -Government support through policy and incentives.  -Community organization involvement in awareness. |
| **Public Perception and**  **Stakeholder Engagement** | -Public perception as key to strategy success.  -Stakeholder engagement leading to robust and accepted solutions. |
| **Climate Change Risks Communication Strategies** | -Clarity and transparency in communication.  -Targeted messaging based on audience.  -Importance of timely communication. |

Source: Field Survey October, 2024

The NVivo 12 analysis (Table 4) reveals significant concerns among respondents about property damage and long-term value decline due to climate change in commercial real estate. Stakeholders recognize the risks from rising temperatures and climate unpredictability, highlighting the necessity for proactive measures, which aligns with Franziska (2020) on transition risks and adaptation needs. A key theme is the financial balancing act between adaptation costs and the risks of inaction. Economic challenges of upgrading infrastructure were noted, alongside pressures like regulatory compliance and the demand for sustainable properties, as observed by Fuerst and Warren-Myers (2018).

The analysis emphasizes shared responsibility between the private sector and government in climate adaptation. While property developers lead the effort, government incentives and standards are crucial, supporting Granberg and Glover's (2021) view on collaborative approaches for a "climate-just city." Stakeholder engagement is also essential for successful adaptation strategies, reflecting Gigi's (2020) emphasis on participation. Clear communication tailored to different stakeholders is vital, aligning with Gareth and Hayfield's (2020) findings on adaptable communication strategies. In summary, while financial concerns challenge climate adaptation, regulatory pressures and stakeholder demand drive strategy adoption, underscoring the importance of collaboration and effective communication.

***Future of Climate Resilience***

**Table 5: Analysis of the Responses on Future Climate Resilience**

|  |  |
| --- | --- |
| **THEME** | **SUB-THEME** |
| **Commercial Real Estate Climate Change Enhancement** | -Infrastructure modernization (insulation and cooling systems).  -Green spaces to mitigate the heat island effect.  -Energy-efficient designs and renewable energy adoption. |
| **Role of Technology in Climate Change Enhancement** | -Smart building systems for real-time adaptation.  -AI-powered climate prediction tools.  -Energy management technologies for efficiency. |
| **Lessons from other Regions** | -Green buildings and sustainability models from Singapore.  -Advanced energy-efficient designs from Northern Europe.  -Renewable energy integration from the U.S. |
| **Role of Education** | - Educational programs for property owners and developers. |
| **Recommendation on Climate Resilience Enhancement** | -Stronger building regulations for climate resilience.  -Tax incentives for retrofitting buildings.  -Investment in research for climate-adaptive materials. |

Source: Field Survey October, 2024

The NVivo qualitative analysis identified infrastructure upgrades as the primary area for enhancing climate resilience in commercial real estate. Respondents emphasized the need for retrofitting with sustainable designs and incorporating green spaces and energy-efficient systems, reflecting the findings of Changsoon, Pam, and Alison (2021). Smart building technologies and energy management systems were highlighted as critical, with AI for climate pattern prediction noted by Bunten and Kahn (2017) as essential for adaptability.

International models like Singapore’s green technologies and Northern Europe’s energy-efficient materials were cited as valuable lessons, aligning with Carmona (2021) on global best practices. The role of education in promoting adaptation was also emphasized, with workshops recommended to raise awareness, consistent with insights from Cobbinah and Anane (2016). Respondents called for stricter building codes and government interventions, such as tax incentives, resonating with Civic Response (2022) on the necessity of policy frameworks.

In summary, Table 5 indicates that infrastructure upgrades, smart technologies, global best practices, education, and government intervention are vital to addressing the challenges of climate change in commercial real estate.

**5.0 CONCLUSION**

To address the impact of temperature and rise on commercial real estate in Kotei and Ayeduase, the following strategies are recommended. Enhancing building resilience requires upgrading structures with climate-resilient materials, such as reflective roofing, improved insulation, and energy-efficient cooling systems, alongside routine maintenance to mitigate climate-related deterioration. Improving energy efficiency involves investing in renewable energy sources, and advanced cooling systems, and promoting energy conservation practices among tenants to reduce operational costs and environmental impact. Strengthening tenant and property management focuses on enhancing tenant satisfaction through flexible lease terms and climate-adaptive amenities while equipping property managers with climate resilience strategies. Engaging in policy and advocacy entails supporting climate-resilient policies, enforcing sustainable building codes, and collaborating with stakeholders to promote climate adaptation initiatives. Investing in research and innovation encourages studies on climate-resilient building technologies and adaptation strategies to enhance long-term sustainability in commercial real estate. Further research should explore the long-term economic impacts of climate change on commercial properties, compare adaptation strategies across regions, assess policy effectiveness, and integrate climate models into real estate planning for informed decision-making.

This paper addresses a critical and timely issue: the impact of climate change, specifically rising temperatures, on commercial real estate in urban areas of Ghana. It contributes to the scientific community by providing empirical insights into stakeholder perceptions, climate risks, and adaptation strategies in a region of Sub-Saharan Africa that is underrepresented in climate-resilient real estate research. The study’s focus on Ayeduase and Kotei, Ghana, fills a knowledge gap by offering localized data that can inform urban planning and real estate development in similar tropical, urbanizing contexts. Furthermore, its integration of resilience theory and practical recommendations enhances its value for advancing sustainable development in the face of escalating climate challenges.

This research has successfully examined the impact of temperature rise on commercial real estate, highlighting increased cooling costs, material degradation, and tenant retention challenges. Stakeholders recognize the urgency of addressing climate risks, emphasizing the need for sustainable adaptation strategies. The study underscores the importance of climate-resilient designs, energy-efficient technologies, and proactive policy measures to enhance sustainability. By adopting these recommendations, the commercial real estate sector can better withstand climate challenges while ensuring long-term viability.

**Consent:**

Written informed consent was obtained from all respondents before data collection, and the collected data were anonymized to protect participants' identities.

**Disclaimer (Artificial intelligence)**

Authors hereby declare that generative AI technologies such as Large Language Models have been used during the editing of this manuscript. The AI tool used was ChatGPT (GPT-4). AI assistance was limited to language refinement, and clarity improvements. No AI-generated content was included in the original research findings, analysis, or data interpretation.

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