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Exploring climate adaptation in UAE residential communities: temperature trends, awareness, and technology adoption

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Introduction: This study investigates how rising temperature trends influence climate adaptation behaviors in residential communities across the United Arab Emirates (UAE). It specifically examines the roles of community awareness, socio-economic status, and climate change perception in shaping household-level responses to heat stress and environmental variability.

Methods: Temperature records from 1950 to 2100 were analyzed to capture long-term warming patterns and seasonal variability. A survey of 550 households was conducted to assess adaptation behaviors, with responses analyzed using Spearman's rank correlation, linear regression, ANOVA, logistic regression, and multinomial logistic regression.

Results: Findings show significant long-term warming trends in the UAE. Survey data indicate that perceived heat discomfort negatively correlates with thermal comfort and strongly motivates technology adoption ($\rho = -0.29$, $p < 0.001$). Community awareness significantly predicts sustainable indoor and outdoor practices ($p < 0.001$). Higher income and education levels are associated with broader adoption of adaptation measures ($p < 0.01$). Climate change perception directly influences adaptation behaviors ($p = 0.032$), while health-related motivations substantially increase the likelihood of adopting technologies (Odds Ratio = 2.87, $p < 0.05$). Logistic regression further reveals that heat perception and energy cost concerns drive solar panel adoption, whereas sand and dust prevention measures improve residential comfort ($p < 0.05$).

Discussion: The results highlight the importance of socio-economic and perceptual factors in shaping adaptation strategies. Effective policy approaches should emphasize community awareness, inclusive planning, and targeted financial incentives to strengthen resilience in hot-arid residential contexts.

KEYWORDS

climate adaptation, sustainable practices, UAE residential communities, temperature trends, climate-responsive technologies, socio-economic factors

1 Introduction

The increasing global temperatures attributed to climate change have significant implications for residential communities worldwide (Herring et al., 2012; Henriques, 2024; Bardan, 2024; Kayaga et al., 2021), particularly in regions like the United Arab Emirates (UAE), where the desert climate exacerbates heat-related challenges.

Understanding the dynamics of climate adaptation and the adoption of sustainable practices within residential communities is crucial for mitigating the adverse effects of rising temperatures and ensuring long-term environmental and societal resilience.

Recent research has increasingly focused on analyzing the thermal environment and its impacts in the UAE (Alkaabi et al., 2024a, 2024b; Sarrau et al., 2024; Farooq et al., 2023). Various tools, such as thermal drones and thermal cameras, have been employed to explore the thermal environment (Alkaabi et al., 2023; Alkaabi and Mohsin, 2022). However, there is limited research that comprehensively examines how individuals perceive and respond to heat-related challenges in residential communities in the UAE.

This study aims to explore the factors influencing the adoption of climate-responsive technologies and sustainable practices in UAE residential communities. While prior research has examined the thermal environment and energy consumption trends in the region, there remains a critical gap in understanding how socio-economic characteristics, climate change perception, and health-related experiences shape individual and household-level adaptation behaviors. Existing studies have largely focused on technical or urban-scale interventions, often neglecting the behavioral and perceptual dimensions of residential climate adaptation. This research addresses that gap by integrating climate data with household survey responses and applying robust statistical modeling to uncover the social drivers of technology adoption and sustainable behavior. In doing so, it contributes to the growing body of knowledge by offering a holistic, data-driven framework for analyzing climate adaptation in hot-arid, residential contexts. The findings offer actionable insights for policymakers, urban planners, and sustainability advocates, particularly in similar Gulf and Middle Eastern settings.

2 Literature background

2.1 Temperature and response to climate-responsive technologies

There is substantial evidence that global warming is occurring. According to the International Panel on Climate Change, there will be a gradual rise in the average temperature of the planet by the end of the 21st century. This rise in temperature will affect the built environment, especially regarding the energy needed for building air conditioning (Radhi, 2009).

The impact of increasing temperature on the adoption of climate-responsive technologies in UAE residential communities is a complex issue. Radhi (2009) and Shanks (2018) both highlight the potential increase in energy consumption for cooling buildings due to increasing temperature, with Shanks (2018) specifically projecting a 22.2% increase in cooling demand by 2050. However, Elkhazindar et al. (2022) and Mohammed et al. (2020) provide a more nuanced view, emphasizing the role of urban form and the urban heat island effect in influencing temperature and thermal comfort. These studies suggest that while increasing temperature may drive the need for climate-responsive technologies, other factors such as urban design and local climatic parameters also play a significant role.

To address these challenges, the UAE is implementing various initiatives to mitigate and adapt to the temperature rise (Ashour et al., 2022). These initiatives include the adoption of climate-responsive technologies, as demonstrated by the BAITYKOOL project, a self-sustaining solar house that uses a range of passive and active strategies to enhance thermal comfort and reduce energy consumption (Samuel et al., 2019). In addition, regional planning responses have been proposed, including decentralizing populations to inland areas (Bolleter et al., 2021), which will be essential in mitigating the impact of rising temperatures on society and the environment in the UAE (Ashour et al., 2022).

Adding further to the discourse, Farooq et al. (2023) explored the radiative sky cooling (RSC) potential across GCC countries, including the UAE. Their research produced a resource map highlighting annual and seasonal RSC capacities, revealing that the region's climate—particularly at night—supports passive cooling through thermal radiation to the sky. The UAE demonstrated a robust annual average RSC power of 82.60 W/m^2, with nighttime RSC reaching 92.74 W/m^2, approximately 18% higher than daytime values. These findings underscore the feasibility of integrating RSC technologies into residential cooling strategies, offering a sustainable alternative to conventional air conditioning, especially under the intensifying heat stress of urbanized environments.

While these studies contribute to the understanding of temperature impacts and mitigation responses in the UAE, a review of extant literature reveals a consistent gap in integrating socio-economic and behavioral dimensions into climate adaptation research. As summarized in Table 1 below, much of the existing work prioritizes technical assessments—such as energy modeling, urban morphology, or pilot projects—while underexploring how residents perceive, respond to, or are enabled to adopt climate-responsive technologies. This gap highlights the need for studies that bridge environmental data with community-level adaptation behaviors.

2.2 Community awareness drives sustainable practices

Findings in the literature have shown the significance of community awareness and involvement in climate adaptation measures. For instance, Khatibi et al. (2021) found that community awareness regarding climate adaptation measures is essential for implementing sustainable practices successfully. However, there is a significant gap in public engagement and knowledge about these measures, especially among citizens and politicians, who are less aware than urban climate experts, planners, or designers (Lenzholzer et al., 2020). This lack of awareness hinders effective planning and implementation of climate change adaptation policies (Moser and Pike, 2015). To manage this, capacity building in effective stakeholder engagement is required, particularly at the local level (Moser and Pike, 2015), as well as media campaigns, further education, and display of good practice (Lenzholzer et al., 2020). In addition, community-based approaches to adaptation, which emphasize participatory planning and implementation, can help promote sustainability and reduce vulnerability to climate-related hazards (Uitto and Shaw, 2006). Lenzholzer et al. (2020) also pointed out that politicians should work on better laws and

TABLE 1 Summary of UAE climate adaptation literature: Focus areas and identified gaps.

Study/Source	Focus area	Identified gaps
Radhi (2009)	Examined the impact of rising temperatures on energy demand for air conditioning	Did not investigate behavioral or socio-economic responses to climate stress
Shanks (2018)	Projected a 22.2% increase in cooling energy demand in the UAE by 2050	Lacked integration of human perception and behavioral adaptation into energy modeling
Elkhazindar et al. (2022)	Analyzed the role of urban morphology and UHI effects on thermal comfort	Limited exploration of how these insights translate to household-level adaptive practices
Al Blooshi et al. (2020)	Surveyed public awareness regarding climate change and its effects on consumption	Awareness was not clearly linked to behavioral implementation or adaptive technology adoption
AboulNaga and Elsheshtawy (2001)	Compared sustainability of traditional vs. contemporary buildings in the UAE.	Focused on architectural form; lacked behavioral or socio-economic analysis
Mohammed et al. (2020)	Proposed design-based strategies for climate-responsive urban planning	Provided conceptual frameworks without empirical testing of resident adaptation
Samuel et al. (2019)	Presented BAITYKOOL, a solar prototype house using passive and active strategies	Case-specific innovation; findings are not generalizable to broader UAE residential trends
Ashour et al. (2022)	Reviewed UAE's national climate mitigation and adaptation initiatives	Did not assess how these initiatives influence or are adopted at the household level
Bolleter et al. (2021)	Advocated population decentralization to mitigate climate impacts	Planning-level recommendation without resident behavior engagement or validation
Alkaabi et al. (2023), Alkaabi and Mohsin (2022)	Used thermal drones and cameras to monitor environmental temperature variations	Tool-centric approach; lacked integration with socio-economic and behavioral dimensions
Farooq et al. (2023)	Mapped radiative sky cooling (RSC) potential across the GCC using meteorological parameters	Did not examine how radiative cooling solutions are perceived or adopted by households

their enforcement, and urban climate experts should focus on good knowledge communication. Rahman (2020) further supports this, stressing the importance of community involvement in achieving environmental sustainability and the role of government, education, and law-making.

Research in the UAE has shown a high level of awareness about climate change and its impact on energy consumption (Al Blooshi et al., 2020). Over 50% of the survey participants stated that their energy and water consumption is affected by climate change. Additionally, almost half of the participants considered moving to a different city if energy prices rose due to the impact of climate change and energy consumption (Al Blooshi et al., 2020). On the other hand, AboulNaga and Elsheshtawy (2001) underscores the need for more sustainable building practices in the UAE, particularly in the residential sector, as the average energy use per square meter in domestic buildings is high. They stated that traditional buildings have been more sustainable than contemporary ones. However, a study by van Kasteren (2014) in Australia indicates that this awareness does not necessarily translate into action, as there is a lack of engagement with climate adaptation measures, particularly in the residential sector. This conclusion supports the finding that the perception of sustainability in residential buildings is influenced by economic and environmental factors but not necessarily by awareness of climate adaptation measures (Abuzaid et al., 2022).

2.3 Socio-economic dynamics in climate adaptation

Earlier research showed that socio-economic factors significantly influence the level of climate adaptation practices. On this matter, Semenza et al. (2008) asserted that although people are generally aware and concerned about climate change, their behavior towards adapting to it is influenced by several factors such as education, age, and location. A study related to farming in Eastern Kenya found that several socio-economic factors influence the level of adaptation to climate variability in the dry zones (Mugi-Ngenga et al., 2016). These factors include the average size of land under maize, farming experience, household size, household members involved in farming, education level, age, main occupation, and gender of the household head. This conclusion is supported by the work of Ndamani and Watanabe (2016) who found that education, household size, income, access to information, credit, and membership in farmer-based organizations are key determinants of farmers' adaptation to climate change.

Another relevant study in Nigeria by Afon et al. (2016) observed that residents from different socio-economic backgrounds, particularly those with varying education levels and income groups, had different mean scores but similar responses to climate change effects. The adaptive strategies adopted were reactive instead of anticipatory. The most significant adaptive strategies were repairing/replacing damaged properties, eliminating waste dumping in drains, and listening to information about climate change. Adaptive strategies in various residential areas were similar but varied in magnitude, denoted by the resident response index (RRI) RRI c = 3.35, RRI t = 3.46, and RRI s = 3.55.

In UAE, Al Blooshi et al. (2020) found that residents in Abu Dhabi are aware of the impact of climate change on their energy consumption, with older (respondents over 40 years) individuals being more conscious. This suggests that age may be a significant factor in climate adaptation practices. However, the specific socio-economic factors influencing these practices in the UAE are not well-documented. Further research is needed to explore the role of income, education, and occupation in shaping climate adaptation strategies in the UAE.

2.4 Climate change perception and behavior

Previous studies identify that direct experience influences risk perception, learning, and action. Studies on climate change perception and behavior in the UAE are limited, but research from other regions suggests that people who have experienced climate-related events, such as flooding, are more concerned and take more action on climate change (Spence et al., 2011). However, Weber's (2010) research suggests that our perception of climate change is influenced by our worldview and political ideology, which can affect how we interpret climate events. According to her study, decisions that are based on moral or social responsibility may be more effective for promoting sustainable action. Semenza et al. (2008) add that while awareness and concern about climate change are high, behavior change is influenced by factors such as education, age, and location. Another survey in South England by Whitmarsh (2008) examines the impact of flooding and air pollution experiences on individuals' responses to climate change, with air pollution victims showing higher pro-environmental values and more significant behavioral responses than flood victims. These studies collectively suggest that while UAE residents may be concerned about climate change, their behavior towards climate adaptation is likely influenced by various factors.

2.5 Heat reduction practices in residential areas

Research has shown that various heat reduction efforts, such as cool and green roofs, shade trees, and outdoor temperature monitoring, can be effective in reducing outdoor air temperatures. In this regard, Detommaso et al. (2019) conducted a micro-scale analysis to identify the effectiveness of cool and green surfaces as strategies for diminishing the outdoor air temperature and enhancing urban wellbeing conditions. They found that cool materials, such as roofs and pavements, can reduce environmental temperatures by about 1.0 °C. Similarly, Porritt et al. (2011) found that wall insulation, solar heat gain reduction, and lighter colored external walls were particularly effective in reducing overheating in houses. On the other hand, Shahidan et al. (2012) reported the importance of tree canopy density and cool ground materials in reducing urban air temperatures and building cooling loads and Yang and Lin (2016) further emphasized the significant impact of planting trees in reducing physiologically equivalent temperatures in outdoor spaces. Zhao et al. (2018) supported these findings, demonstrating the cooling benefits of tree shade on building facades, with specific emphasis on the location and arrangement of trees. The importance of tree canopy intensity was also confirmed by Misni (2013) who found that heavily landscaped areas around single-family houses can reduce heat build-up by as much as 4 °C. However, Morakinyo et al. (2017) noted that the effectiveness of green roofs in reducing outdoor temperatures and cooling demand varies depending on the type of green roof and the prevailing climate. These findings collectively support the positive correlation between the effectiveness of heat reduction efforts and the implementation of practices such as planting shade trees, using light-colored roofing materials, and conducting outdoor temperature monitoring.

2.6 Heat-related health and climate-responsive technologies: empowering communities for resilience

Numerous studies have investigated the correlation between adopting climate-responsive technologies and heat-related health problems. Mao et al. (2018) and Hernández (2016) underscore the importance of selecting suitable technologies for different climate regions, with Mao et al. (2018) focusing on building technologies and Hernández (2016) on clean heat policies in urban areas. O'Neill et al. (2009) and Harlan and Ruddell (2011) highlight the potential health benefits of these technologies, particularly in mitigating the impacts of heat and air pollution in cities. Specifically, Harlan & Ruddell (2011) mention using heat warning and air quality alert systems, while O'Neill et al. recommend various preventive actions, including using cool environments and modifying the built environment. According to Sampson et al. (2013) and Farbotko and Waitt (2011), residents who have suffered from heat-related health issues are more likely to adopt climate-responsive technologies like air conditioning to deal with extreme heat. However, air conditioning usage can worsen existing inequalities, particularly for vulnerable populations (Farbotko and Waitt, 2011). To address such issues, Brennan et al. (2020) suggest implementing preventative strategies and interventions, such as community-led initiatives and energy-efficient building design. These measures can help reduce the adverse health effects of extreme heat and encourage the adoption of climate-responsive technologies.

On the other hand, some studies, for instance, by Fagan-Watson and Burchell (2016), have stated that community involvement is vital in planning for and responding to heat waves. Effective community-based interventions, such as heat action plans, can significantly reduce heat-related mortality and morbidity, especially among vulnerable populations (Hasan et al., 2021). In addition, Hatvani-Kovacs et al. (2016) noted that a comprehensive framework integrating urban and infrastructure planning, building design, public health, and social research enhances heat stress resilience. Brennan et al. (2020), Pasquini et al. (2020), and Hasan et al. (2021) have shown that residents who have experienced heat-related health issues are more likely to engage in community initiatives for heat resilience. These initiatives can include early warning systems, regional heat plans, and community-led programs (Brennan et al., 2020), and education and awareness campaigns (Hasan et al., 2021). Brennan et al. (2020) and Pasquini et al. (2020) pointed out that vulnerable groups, such as older people and those living in informal settlements, are particularly at risk and can benefit from these interventions. Additionally, green building design strategies, such as those outlined in the Leadership in Energy and Environmental Design (LEED®) rating system, can contribute to community health resilience to extreme heat events (Houghton and Castillo-Salgado, 2019).

2.7 Sand and dust intrusion prevention

Research has shown that the incorporation of features to prevent sand and dust intrusion into homes is crucial for a comfortable and clean-living environment in desert regions. For example, in the UAE, El Amrousi et al. (2023) found that adding a fence around small gardens in industrial neighborhoods in Mussafah (a desert city in Abu Dhabi) substantially decreased the effects of sand pollution. They observed that shrubs and green fences in front of buildings reduced sand accumulation by nearly 34% compared to a run with buildings of the same height and without fences. Similarly, Dun et al. (2021) proposed settlement systems with brick, solar panels, and building arrays to prevent wind-sand disasters. Their study showed that brick arrays effectively fix and block sand up to 3–4 m, while solar panel arrays can reduce energy efficiency due to sand deposition. Thus, the optimal configuration is to place brick arrays upwind, solar panel arrays in sand deposition areas, and building arrays downwind. Earlier research in residential houses in Kuwait City also suggested that increasing home insulation can effectively reduce indoor exposure to dust storm particles (Yuan et al., 2020).

Another recent study suggests utilizing geometric planes in building design to reduce dust intrusion, especially around industrial sites (Maharani et al., 2022; Al-Sallal and Al-Sallal, 2014). Likewise, Stetsenko and Yastrebova (2018) underscores the influence of urban planning and building factors on the dustiness of the urban environment, advocating for the use of front-finishing materials with low dust deposits and high self-cleaning ability. Moreover, while Artmann (2014) underlines the significance of high-quality ground construction to improve impermeability and environmental protection, Bernal et al. (2020) highlight the function of natural and mechanical ventilation in minimizing dust exposure at the housing scale.

Bernal et al. (2020) finding corroborates with Achilleos et al. (2023), who opined that using air purifiers and decreased ventilation during desert dust storms significantly reduces indoor exposure to particles, improving indoor air quality. However, dust storms can still lead to increased concentrations of bacteria and fungi in indoor and outdoor environments, particularly in arid regions (Soleimani et al., 2016), causing significant environmental and health impacts, including respiratory and cardiovascular issues (Nazari et al., 2016). The intensity and duration of dust storms can further affect indoor particulate matter concentrations, with higher levels during intense events (Krasnov et al., 2015). While air purifiers can help mitigate the effects of dust storms, a comprehensive procedure incorporating indoor and outdoor strategies is necessary to create a comfortable and clean-living environment in desert regions.

2.8 Solar panel adoption factors

Numerous factors have been found in the literature to influence solar panel installation and adoption for power generation. According to research by Zander et al. (2019) in Australia and Wittenberg and Matthies (2016) in Germany, these factors include installation costs, financial incentives, and the potential for self-consumption. These factors may outweigh the influence of abundant sunlight and the desire to reduce energy costs. Furthermore, environmental factors such as insulation, air temperature, wind speed, and relative humidity (Adeh et al., 2019) can affect the potential for solar power generation. However, these environmental factors may not be the primary drivers of solar panel installation.

According to Faiers and Neame (2006), people's perceptions and attitudes are crucial in adopting solar panels. Their research conducted in the UK identified financial, economic, and aesthetic factors as barriers to adoption, suggesting that consumers need to see a clear advantage in solar power to adopt it. Similarly, Shakeel & Rajala (2020) recognize various factors influencing the adoption of solar photovoltaics (PV) in households, including technological advancements, performance improvements, price reductions, and policy support. Nieuwenhout et al. (2001) add a practical dimension, pointing out the need for an adequate service infrastructure and the potential for smaller, more affordable systems in developing countries.

2.9 Climate adaptation in similar Middle Eastern contexts

Climate adaptation challenges in the Middle East share many regional characteristics, such as extreme heat, rapid urbanization, and resource scarcity. Consequently, countries across the region have developed various strategies—ranging from passive design interventions to policy reforms and public education.

In Saudi Arabia, buildings account for nearly 49% of the country's annual electricity consumption (Aldersoni et al., 2022), placing the architectural sector at the forefront of energy conservation. Using simulations of traditional housing in Aldersoni et al. (2022) assessed passive design interventions—including thermal mass walls, outdoor green spaces, optimized window-to-wall ratios, and shading devices—and found they significantly enhanced thermal performance and reduced energy demand in hot-arid environments.

Complementing this, Aloshan (2025) focused on retrofitting existing homes in Riyadh to achieve Near-Zero Energy Homes (NZEH), using DesignBuilder simulations to optimize facade elements such as glazing, shading devices, and thermal insulation. His findings showed that these retrofitting measures reduced annual energy consumption by up to 84% when combined with photovoltaic (PV) systems.

In Jordan, adaptation efforts have increasingly emphasized regulatory compliance and community advocacy. Abdel-Fattah et al. (2022) conducted a survey across 500 residential units in Amman and found that only 5.8% of flats met thermal insulation standards. Their findings, supported by a civil society-led campaign, contributed to policy reform, illustrating the power of grassroots engagement in promoting energy efficiency.

Across the region, socio-economic factors have also been found to play a significant role in shaping climate adaptation efforts. In Egypt, public engagement—particularly among youth—has emerged as a vital element of climate action. Elsharkawy et al. (2023) studied climate change knowledge, perceptions, and practices among students at Al-Azhar University for Girls in Cairo. While most students recognized the impact of climate change and supported basic mitigation actions, only 57.8% had a strong understanding of its causes. A positive correlation was found between knowledge levels and environmentally friendly behaviors, such as energy conservation and public transit use. However, the study highlighted persistent gaps between awareness and action, suggesting the need for more targeted educational strategies to foster effective behavioral change.

At a broader regional scale, nature-based solutions (NbS) are gaining recognition as a critical tool for climate resilience. Ben Hassen and Hageer (2024) examined NbS approaches—such as green roofs, urban vegetation, and sustainable water systems—in MENA cities. They emphasized that NbS can reduce urban heat island effects, enhance air quality, support biodiversity, and promote more resilient urban systems, especially in water-stressed and densely populated environments.

Collectively, these studies illustrate the value of context-specific adaptation strategies that combine traditional design, advanced energy modeling, community engagement, and green infrastructure.

Despite the growing body of regional research, gaps remain—particularly in understanding how socio-economic dynamics and community awareness shape climate adaptation behaviors in UAE residential settings. While much of the literature largely focuses on energy consumption and thermal comfort, fewer studies explore the behavioral and socio- economic drivers behind sustainable action. Addressing these gaps is crucial for developing context-specific, inclusive climate strategies that can inform policy, promote community engagement, and enhance the resilience of residential communities throughout the Emirates.

3 Methodology

This study adopts an integrated mixed-method approach combining climate data analysis with statistical modeling of residential behavior to assess climate adaptation patterns in the United Arab Emirates (UAE). The research is guided by a structured methodological framework consisting of four interconnected stages: (1) climate data acquisition and visualization, (2) survey design and administration, (3) statistical analysis, and (4) data validation and reproducibility. This multi-stage framework supports a comprehensive investigation of both environmental conditions and community-level responses.

3.1 Climate data acquisition and processing

To assess seasonal and long-term temperature trends in the UAE, historical and projected climate data were sourced from the Copernicus Climate Change Service (C3S) through the Climate Data Store (CDS) (Muñoz Sabater, 2019; Wouters et al., 2021). The HadGEM2-CC model from the UK Met Office, part of the CMIP5 archive, was used due to its reliability and suitability for regional climate projections. The datasets are open-source and peer-reviewed, offering coverage from 1950 through 2100.

Temperature data were obtained in NetCDF (.nc) format and processed using the Grid Analysis and Display System (GrADS), version 2.2.1, installed on a Linux-based Ubuntu 22.04 LTS operating system. The preprocessing stage involved the creation of control (.ctl) files using the grads2ctl utility to enable GrADS to interpret the spatial and temporal dimensions of the dataset. GrADS was then used to develop custom scripts that generated climate visualizations. These included spatial temperature distribution maps for the summer season (June to September 2023) and winter season (December 2022 to March 2023), as well as a time series plot of annual mean temperatures across UAE regions from 1950 to 2100.

Additional maps were created to reflect seasonal variations in temperature by comparing conditions across two periods—2015–2019 and 2020–2024 for both summer and winter. These comparative visualizations insight into how short-term climate dynamics are evolving within the UAE context, particularly highlighting spatial shifts such as localized warming or cooling trends. These outputs offer a critical empirical foundation for contextualizing and interpreting the behavioral patterns observed in the household-level climate adaptation data.

3.2 Survey design and administration

To explore household-level climate adaptation behaviors, a structured questionnaire was developed, targeting three thematic areas: demographic and socio-economic characteristics, perceptions and awareness of climate change, and the adoption of heat mitigation and sustainability practices. The survey was prepared in both Arabic and English and was administered to a sample of 550 households across the UAE during October and November 2023. A representative convenience sampling technique was used to ensure diverse regional and demographic representation.

The survey included questions across three main domains:

1. Demographic and socio-economic data (e.g., income, education, household size, type of residence),
2. Perceptions and awareness of climate change, including knowledge, concern, and familiarity with adaptation strategies,
3. Adoption of heat mitigation practices, including solar panels, landscaping, indoor cooling adaptations, and dust intrusion prevention.

Of the surveyed households, 63% were located in the Emirates of Abu Dhabi and Ras Al Khaimah. Educational attainment was high: 67% of respondents reported holding a bachelor's degree, and 20% held graduate-level qualifications. Regarding income, 60% of households reported a monthly income between 30,000 and 50,000 AED. Most respondents (87%) lived in villas with private gardens or yards. In terms of household size, 68% of households had more than six members, while 24% had between four and five members.

To assess the reliability of the questionnaire, Cronbach's alpha was calculated. The internal consistency of the dependent variables group was acceptable, with a reliability coefficient of $\alpha = 0.689$. A similar level of reliability was recorded for the independent

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TABLE 2 Overview of research hypotheses and statistical procedures.

Research hypothesis	Statistical procedure
H1: Temperature comfort influences the adoption of climate-responsive technologies	Spearman's rank correlation, Simple linear regression
H2: Greater community awareness positively correlates with increased adoption of sustainable practices in UAE residential communities	Correlation analysis, Linear regression
H3: Socio-economic factors, such as income and education, significantly impact the level of climate adaptation practices in UAE residential communities	ANOVA, Tukey multiple comparison
H4: A linear relationship exists between residents' perception of climate change and their behavior towards climate adaptation measures	Linear regression
H5: The effectiveness of heat reduction efforts outside or around houses and inside are positively correlated with the implementation of practices such as planting shade trees, using light-colored roofing materials, and conducting outdoor temperature monitoring	Linear regression
H6: Residents who have experienced heat-related health issues, such as heatstroke or dehydration, are more likely to adopt climate-responsive technologies and engage in community initiatives for heat resilience	Multinomial logistic regression
H7: The incorporation of features to prevent sand and dust intrusion into homes contributes to a more comfortable and clean-living environment, particularly in desert regions	Linear regression
H8: The installation of solar panels for solar power generation is influenced by factors such as heat perception and the desire to reduce energy costs	Chi-square independence test, Logistic regression

variables group, with $\alpha = 0.662$. These results affirm the validity and consistency of the survey instrument for further statistical analysis.

3.3 Statistical analysis

Statistical analysis was conducted using R version 4.2.2 on the Linux system. The research hypotheses were tested using:

- Spearman's rank correlation and simple linear regression (e.g., for heat perception and technology adoption),
- ANOVA and Tukey's *post hoc* tests (e.g., for socio-economic group differences),
- Multinomial logistic regression (e.g., for health-related influences on technology use),
- Chi-square independence tests (e.g., for solar panel adoption drivers).

Table 2 summarizes each hypothesis and its associated statistical technique, while Table 3 categorizes the corresponding survey questions into independent (predictor) and dependent (outcome) variables for analysis.

3.4 Data validation

This study utilized both secondary (climate) and primary (survey) data sources, with a clear emphasis on transparency, reproducibility, and methodological rigor.

The climate data are publicly available and peer-reviewed:

- Datasets were retrieved from the Copernicus Climate Data Store (CDS) at https://cds.climate.copernicus.eu/,
- The HadGEM2-CC model was accessed through the CMIP5 archive, maintained by the UK Met Office.

These sources are widely recognized for their scientific integrity and are extensively used in global climate modeling and assessments.

For the primary survey data, reliability and ethical considerations were carefully addressed. The survey was pretested for clarity and relevance, and all respondents provided informed consent. The use of convenience sampling is acknowledged as a limitation regarding generalizability; however, the large and demographically diverse sample enhances the study's internal validity.

To structure the survey questions into independent and dependent variables suitable for the statistical linear modeling and predictions. Table 3 identify the predictors (independent variables) and outcomes (dependent variables) based on the hypotheses outlined. The variable MHR is used as a dependent variable in certain hypotheses and as an independent variable in Hypothesis 6. This dual role of MHR is justified, as variables that serve as outcomes in some contexts can also function as predictors in others, thereby providing a comprehensive understanding of the interrelationships between different factors.

4 Results and discussion

4.1 Temperature trends in the UAE: seasonal variation and long-term projections

Figure 1a illustrates the average temperatures in the UAE and surrounding regions from June to September 2023, representing

TABLE 3 List of independent variables (predictors) and dependent variables (outcomes).

Independent Variables (Predictors)	Dependent Variables (Outcomes)
1. Demographic Information:	1. Impact Assessment:
- Question (1): In which Emirate of the United Arab Emirates do you currently reside? (Emirates)	- Question (7): Heat Impact on Houses (HIH)
- Question (2): What is the highest level of education completed in your household? (Educ)	- Question (8): Heat Impact on House Garden (HIHG)
- Question (3): Do you or any member of your household have a major in any of the following fields? (Major)	- Question (9): Heat Impact on Indoor Activities (HIIA)
- Question (4): What is your annual household income in AED? (Income)	- Question (10): Heat Impact on Outdoor Activities (HIOA)
- Question (5): What type of house do you currently live in? (HType)	- Question (13): Heat Exposure: Average daily outdoor hours during summer (HeatExp)
- Question (6): Household Size: How many individuals, including all family members and occupants, reside in your household? (HSize)	- Question (23): Heat-Related Health Issues experienced by household members (HealthIssues)
2. Perception and Awareness:	2. Community Resilience and Adaptation:
- Question (11): Level of agreement with the statement: "I believe that climate adaptation measures are essential for the wellbeing of our residential community." (Adapt)	- Question (25): Measures or actions believed to be effective in improving heat resilience and comfort in the residential community (MHR)
- Question (14): Rating of overall awareness of climate change and its potential impacts on the community. 1: No awareness to 6 very high awareness	- Question (26): Primary motivation for adopting climate-responsive technologies (MOTCRT)
- Question (12): Heat Perception (Perception): Overall perception of the heat during the summer months. 1: Very unpleasant to 5 Very pleasant	- Question (27): Climate adaptation measures implemented in the residential community (AdaptMeas)
- Question (15): Attendance of community workshops, seminars, or educational events focused on climate adaptation and resilience (Knowledge)	- Question (28): Barriers hindering the adoption of climate adaptation practices in the residential community (BarrierAdopt)
- Question (16): Familiarity with climate adaptation measures (FamClimAdapt)	
- Question (17): Frequency of engaging in discussions about climate-related issues and adaptation strategies (DiscussCL)	
- Question (18): Awareness of local initiatives or organizations working on climate adaptation and resilience (LocInitAware)	
- Question (24): Community Engagement: Involvement in community initiatives or groups focusing on heat resilience and climate adaptation (ComEngagement)	
3. Heat Mitigation Measures and Environmental Practices:	
- Question (19): Heat Mitigation Measures implemented indoors (HMMII)	
- Question (21): Heat Mitigation Measures implemented outdoors (HMMIO)	
- Question (20): Measurement of the effectiveness of indoor heat reduction efforts (MEffIHR)	
- Question (23): Measurement of the effectiveness of outdoor heat reduction efforts (MEffOHR)	
- Question (29): Sand and Dust Resistance in the home (SandDust)	
- Question (30): Desert Rainwater Harvesting implementation (DRHI)	
- Question (31): Solar Power Generation implementation (SOLAR)	
- Question (32): Efficient Landscaping practices (LANDSC)	

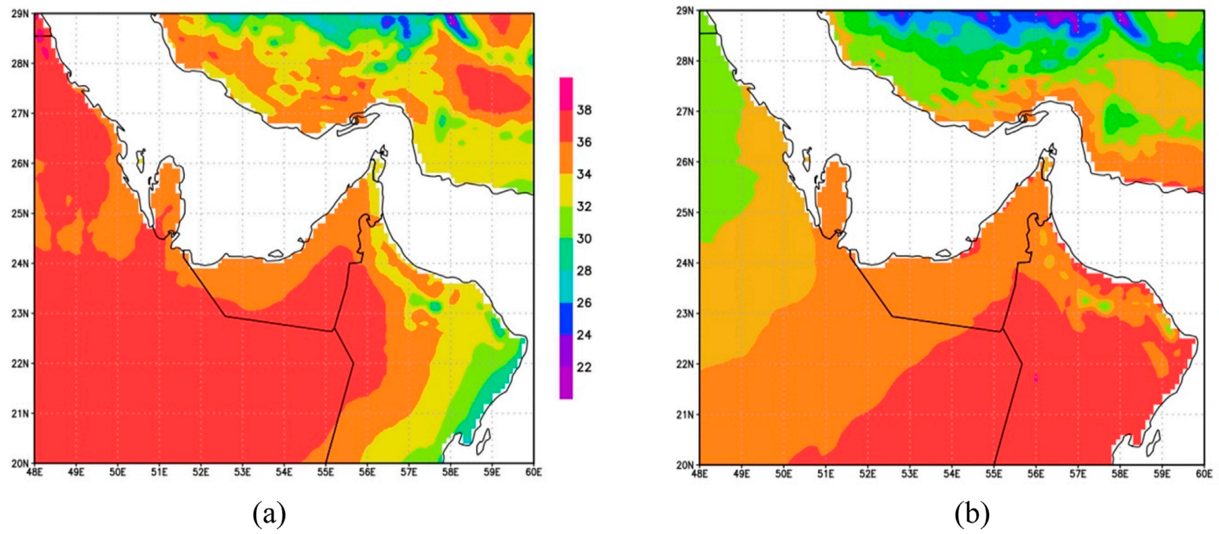


FIGURE 1
Seasonal temperature variations in the UAE: **(a)** Average summer temperatures (June-September 2023) and **(b)** Average winter temperatures (December 2022-March 2023).

the summer season. The temperature values, measured in Celsius, range from 32 to 38° on average across the UAE. The color gradient indicates varying temperature zones, with red hues representing higher temperatures and green to blue hues indicating cooler areas. The UAE predominantly experiences high temperatures, highlighted by the widespread red and orange areas, which depict the intense summer heat typical of the region. In contrast, Figure 1b displays the average temperatures recorded across the UAE from December 2022 to March 2023, covering all hours of the day and representing the winter season. During this period, temperatures average between 18 and 24 °C across the UAE.

4.2 Interpretation seasonal temperature averages (summer and winter: 2015–2019 vs. 2020–2024)

The spatial temperature maps (Figures 2a,b) compare summer temperatures averaged over the entire month for every hour of the day, across two five-year periods: 2015–2019 and 2020–2024. Overall, the average temperature patterns across the UAE remain generally consistent between the two periods.

However, a noticeable difference appears in the areas around Dubai, where average temperatures from 2020 to 2024 are slightly lower—by approximately 0.5 °C–1.0 °C—compared to the 2015–2019 period. While this difference is relatively small, it is consistent enough to suggest a localized cooling trend.

Several factors may have contributed to this slight decrease in temperature around Dubai during the latter period. One possible influence is the COVID-19 pandemic, which began in early 2020 and led to a temporary slowdown in industrial activity, reduced traffic emissions, and overall lower human activity. These changes could have slightly reduced the urban heat island effect in highly developed areas like Dubai.

Additionally, other factors such as increased urban greening efforts, changes in land use, expansion of cooling infrastructure, or improvements in environmental regulations may have played a role in modulating local temperatures. Despite these changes near Dubai, the broader temperature trends across the country remain largely unchanged, indicating that this cooling is likely a regional and temporary anomaly rather than a widespread climatic shift.

Similarly, the winter maps (Figures 2c,d) show a rise in baseline temperatures across the country. Cooler zones, particularly in the northern and mountainous regions, show a reduction in spatial extent, indicating milder winters. While the warming is not extreme, it may suggest early signs of shifting seasonal behavior, with winters becoming slightly milder across the region. Continued monitoring and analysis would be needed to determine if this is part of a longer-term trend or a short-term variation. These changes collectively reflect the broader impacts of regional climate change, emphasizing the importance of adaptation strategies in residential communities.

Figure 3 shows a time series plot of the UAE's annual mean temperature from 1950 to 2100, sourced from the HadGEM2-CC model (UK Met Office) (Wouters et al., 2021). The vertical axis ranges from 25 °C to 31 °C, while the horizontal axis spans the years. From 1950 to 1980, temperatures fluctuate around 26 °C–27.5 °C. From the 1980s onward, there is a noticeable upward trend, with significant increases after 2000. By 2100, temperatures are projected to exceed 30 °C, indicating a substantial rise likely due to global warming, with significant implications for the region's climate. Therefore, the subsequent section explores how these variations influence the adoption of climate-responsive technologies in residential communities.

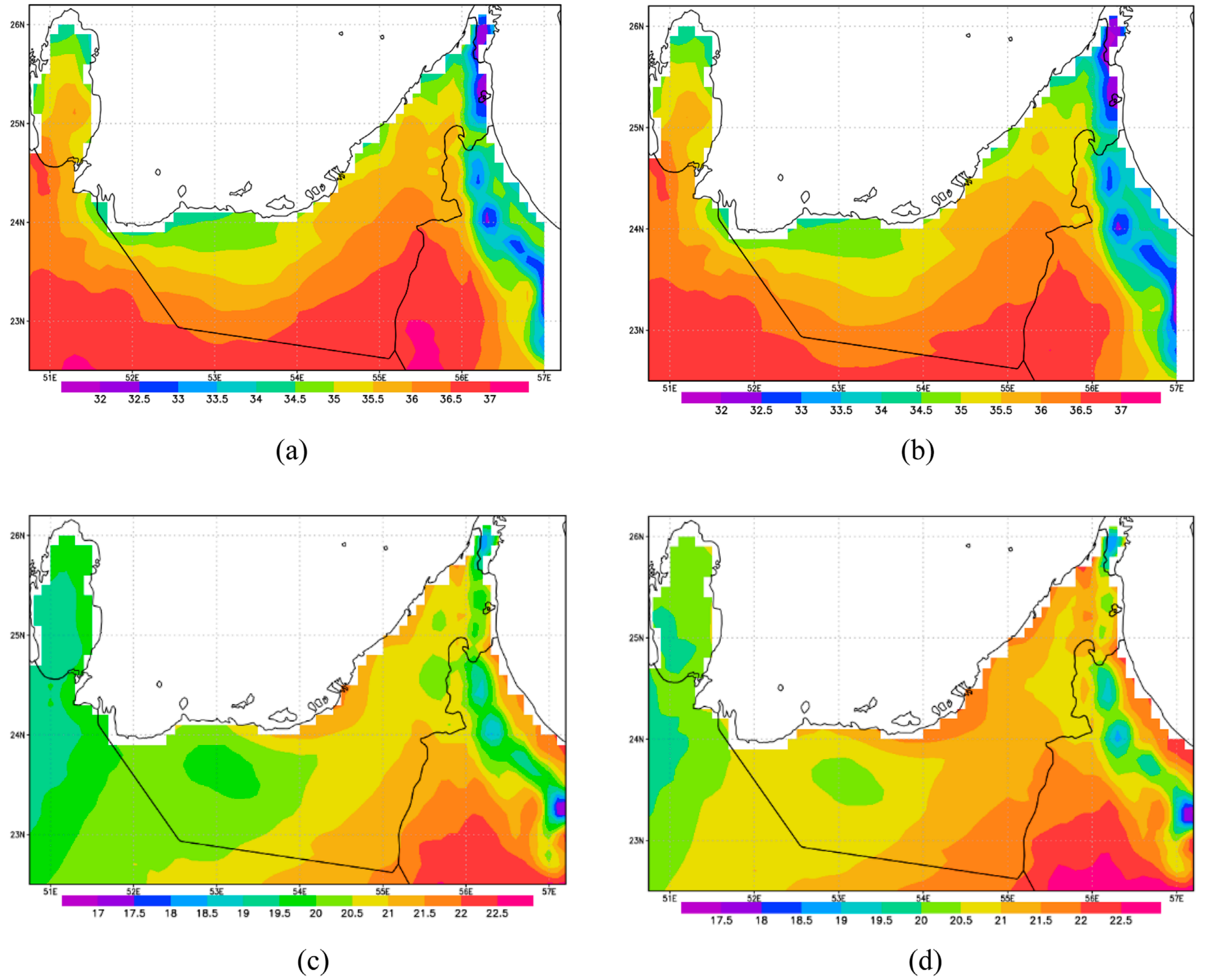


FIGURE 2
Spatial distribution of average seasonal temperatures across the UAE for two time periods 2015–2019 and 2020–2024. Panels **(a)** and **(b)** show summer temperatures; panels **(c)** and **(d)** show winter temperatures. **(a)** Average summer temperatures (2015-2019). **(b)** Average summer temperatures (2020-2024). **(c)** Average winter temperatures (2015-2019). **(d)** Average winter temperatures (2020-2024).

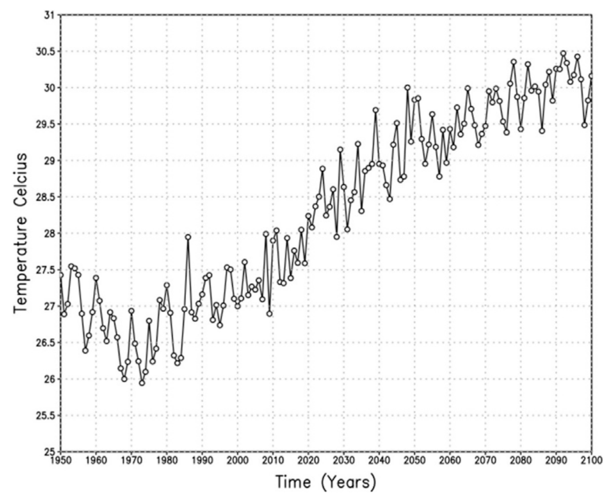
4.3 Influence of temperature on adoption of climate-responsive technologies

To analyze the research hypothesis "H1: Temperature comfort influences the adoption of climate-responsive technologies in UAE residential communities," the adoption of climate-responsive technologies is assessed through question Q25 (MHR) in the questionnaire: "What measures or actions do you believe would be most effective in improving heat resilience and comfort in your residential community?", while the perception of increasing temperatures is measured by question Q12 (Perception): "How would you describe your overall perception of the heat during the summer months (June, July, August) in your residential area?"

Temperature variations significantly impact the adoption of climate-responsive technologies in UAE residential communities. The study, centred on perceptual data regarding heat discomfort during summer months and responses related to heat resilience, reveals a negative correlation between increasing temperatures comfort and the adoption of climate-responsive technologies. A non-parametric Spearman's rank correlation yielded a coefficient of −0.29 (p-value = 1.117e-11), indicating a substantial relationship. Utilizing a simple linear regression model, a significant association between rising perceptions of discomfort and increased adoption of climate-responsive technologies was found, as evidenced by the Equation 1:

$$MHR = 3.52 - 0.40\,Perception \tag{1}$$

This suggests that for each unit increase in the perception of heat discomfort, there is a corresponding increase of 0.40 units in the adoption of climate-responsive technologies (Table 4-A).



FIGURES 3
Time series plot of UAE's annual mean temperature (1950-2100) from HadGEM2-CC model (Wouters et al., 2021).

4.4 Community awareness and sustainable practices adoption

Community awareness significantly influences the promotion of sustainable practices within UAE residential areas. To determine awareness of climate change and its implications, respondents rated their awareness levels on an ordinal Likert-scale ranging from 1 to 6, signifying a spectrum from very low (1) to very high (6), as per questionnaire item Q14 (Awareness). Sustainable practices adoption was measured through various questions (predictors) including Q19 (HMMII), Q22 (HMMIO), Q29 (SandDust), Q30 (DRHI), Q31 (SOLAR), Q32 (LANDSC). These practices aimed to mitigate the effects of climate change both indoors and outdoors. Correlation analyses revealed a positive relationship between community awareness and the adoption of sustainable practices. Particularly, the implementation of practices indoors (HMMII) and outdoors (HMMIO) was positively influenced by community awareness, as indicated by significant effects in the two linear regression equations (Table 4-B,C). These findings highlight the importance of increased awareness in driving the implementation of sustainable practices in UAE residential communities. To test the research hypothesis *H2: Community awareness positively affects the adoption of sustainable practices in UAE residential communities;* linear regression (Equations 2, 3) applied as follow:

$$HMMII = 3.54 + 0.19\,Awareness \tag{2}$$

$$HMMIO = 1.78 + 0.17\,Awareness \tag{3}$$

Where:

- Adoption (HMMII) represents the adoption of sustainable practices indoors.
- Adoption (HMMIO) represents the adoption of sustainable practices outdoors.
- Awareness represents the level of awareness of climate change and its implications.

4.5 Impact of socio-economic factors and perception on climate adaptation practices in UAE residential communities

The third hypothesis stated that socio-economic factors, such as income and education, significantly impact the level of climate adaptation practices in UAE residential communities. The effects of Emirates, Income, and Education on Awareness (Q14), measures or actions to improve heat resilience (MHR, Q25), and climate adaptation practices (AdaptMeas, Q27) were tested using the ANOVA method. The results showed that Emirates had no significant effect on Awareness (p-value = 0.114) and MHR (p-value = 0.677) but had a significant effect on AdaptMeas (p-value = 0.0002). Tukey multiple comparison revealed significant differences in climate adaptation measures between RAK and AD (p-value = 0.015) and RAK and Dubai (p-value = 0.005). Income had a significant effect on Awareness (p-value = 0.000), MHR (p-value = 0.000), and AdaptMeas (p-value = 0.0035), with higher income correlating with significant improvements in all three dependent variables. Education also showed a significant effect on Awareness (p-value = 0.0018), MHR (p-value = 0.001), and AdaptMeas (p-value = 0.000), with higher education levels significantly enhancing climate adaptation practices in UAE residential communities.

4.6 Perception of climate change and adaptation behavior

The fourth hypothesis argues that a linear relationship exists between residents' perception of climate change and their engagement with climate adaptation measures. To investigate this hypothesis, the linear relationship between behavior towards climate adaptation measures (AdaptMeas) and residents' perception of climate change (Perception) was analyzed. Employing a linear regression model, a significant linear association between AdaptMeas and Perception was revealed, as outlined in Table 4-D. Notably, an increase in the perception of unpleasantness corresponds to a substantial rise in climate adaptation measures. The linear regression Equation 4 is provided below (Table 5):

$$AdaptMeas = 1.80 - 0.12\,Perception \tag{4}$$

Where:

- Behavior towards adaptation measures (AdaptMeas) represents the behavior of residents towards climate adaptation measures.
- Perception represents residents' perception of climate change.

4.7 Impact of sustainable practices on heat reduction effectiveness in UAE residential communities

The fifth hypothesis states that the effectiveness of heat reduction efforts outside or around houses and inside are positively

TABLE 4 Comprehensive analysis of climate-responsive practices and factors in UAE residential communities.

Variable	Estimate	Std. Error	t value	Pr(>|t|)
A: Effect of Temperature Perception on Climate-Responsive Technology Adoption in UAE Residential Communities				
(Intercept)	3.5235	0.1087	32.4290	0.0000
Perception	−0.3949	0.0615	−6.4235	0.0000
B: Impact of Awareness on Adoption of Sustainable Indoor Practices in UAE Residential Communities (HMMII)				
(Intercept)	3.5375	0.1851	19.1151	0.0000
Awareness	0.1877	0.0474	3.9593	8.5500
C: Impact of Awareness on Adoption of Sustainable Practices Outdoors in UAE Residential Communities (HMMIO)				
(Intercept)	1.7829	0.1427	12.4900	0.0000
Awareness	0.1744	0.0366	4.76940	2.4000
D: Impact of Perception on Behavior towards Climate Adaptation Measures				
(Intercept)	1.7953	0.0965	18.612	0.0000
Perception	0.1172	0.0546	2.1464	0.0323
E: Relationship between the effectiveness of outdoor heat reduction efforts and implementation of practices				
(Intercept)	1.5139	0.1156	13.0935	0.0000
MEffOHR	0.6716	0.0773	8.6848	0.0000
F: Relationship between indoor heat reduction effectiveness and implementation of practices				
(Intercept)	3.7450	0.1821	20.567	0.0000
MEffIHR	0.3987	0.1421	2.805	0.0052
G: Regression Analysis Results for the Influence of Sand and Dust Intrusion Prevention on House Cleanliness and Comfort				
(Intercept)	4.2698	0.0837	51.0271	0.0000
SandDust = 2 (No)	−0.3803	0.1445	−2.6314	0.0088
H: Logistic regression results for solar panel installation and heat perception				
(Intercept)	2.6053	0.2762	9.4327	0.0000
datafin$Perception	−0.3259	0.1367	−2.3842	0.0171

TABLE 5 Impact of perception on behavior towards climate adaptation measures.

Variable	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	1.7953	0.0965	18.612	0.0000
Perception	0.1172	0.0546	2.1464	0.0323

correlated with the implementation of practices such as planting shade trees, using light-colored roofing materials, and conducting outdoor temperature monitoring. Table 4-E shows that linear regression confirms a significant positive relationship between these practices and the effectiveness of heat reduction efforts outside or around houses. Additionally, Table 4-F confirms that implementing practices to reduce heat inside, such as using blackout curtains or blinds, air conditioning, and attic insulation, positively influences the effectiveness of heat reduction inside the house. The linear regression Equations 5, 6 are as follows:

For heat reduction efforts outside or around houses (Table 4-E):

$$MEffOHR = 1.51 + 0.67\,Implementation\ of\ Practices \tag{5}$$

For heat reduction efforts inside houses (Table 4-F):

$$MEffIHR = 3.75 + 0.40\,Implementation\ of\ Practices \tag{6}$$

TABLE 6 Frequency distribution of heat-related health issues.

Frequency Breakdown	Proportion
Frequently	0.2125
Never	0.2429
Occasionally	0.5446

Where:

- MEffOHR represents the effectiveness of heat reduction outside or around houses.
- MEffIHR represents the effectiveness of heat reduction inside houses.
- Implementation of practices represents the implementation of practices such as planting shade trees, using light-colored roofing materials, conducting outdoor temperature monitoring (for Table 4-E), and using blackout curtains or blinds, air conditioning, installing attic insulation (for Table 4-F).

4.8 Impact of heat-related health issues on climate-responsive technologies adoption

The sixth hypothesis assumes that residents who have experienced heat-related health issues, such as heatstroke or dehydration, are more likely to adopt climate-responsive technologies and engage in community initiatives for heat resilience. The variable HealthIssues is a nominal variable with three levels: Frequently, Occasionally, and Never. Table 6 shows that 76% of the sample suffer from heat-related health issues, while the remaining 24% claimed they have never experienced such issues.

To test hypothesis *H6*, a multinomial logistic regression is used to estimate the effect of adopting climate-responsive technologies on the probabilities of having different levels of heat-related health issues. For the model equations, the level *Frequently* is used as the baseline for the odds comparisons. The predictors are MHR and AdaptMeas variables. The model equations are given by

$$ln\left(\frac{P(HealthIssues = Never)}{P(HealthIssues = Frequently)}\right) = \alpha_{10} + \alpha_{11}MHR + \alpha_{12}AdaptMeas$$

$$ln\left(\frac{P(HealthIssues = Occasionally)}{P(HealthIssues = Frequently)}\right) = \alpha_{20} + \alpha_{21}MHR + \alpha_{22}AdaptMeas$$

From Table 7, the fitted model Equations 7, 8 are

$$ln\left(\frac{P(HealthIssues = Never)}{P(HealthIssues = Frequently)}\right) = 2.37 - 4.75MHR + 2.87AdaptMeas \quad (7)$$

$$ln\left(\frac{P(HealthIssues = Occasionally)}{P(HealthIssues = Frequently)}\right) = 3.38 - 2.40MHR + 2.17AdaptMeas \quad (8)$$

In one-unit increase in the predictor MHR is associated with the decrease in log odds of Never vs. Frequently in the amount of 4.75, while in one-unit increase in the predictor AdaptMeas is associated with the increase in log odds of having heat-related health issues Never vs. Frequently in the amount of 2.86. In one-unit increase in the predictor MHR is associated with the decrease in log odds of Occasionally vs. Frequently in the amount of 2.40, while in one-unit increase in the predictor AdaptMeas is associated with the increase in log odds of having heat-related health issues Occasionally vs. Frequently in the amount of 2.17.

To explore the relative risk between the level Frequently and the other two levels, the odds ratio is calculated for both equations given in Table 7-B. The relative risk ratio for one-unit increase in the variable MHR is 0.60 for *never* having heat-related health issues vs. having *frequently* heat-related health issues. For the other predictor, the relative risk for one-unit increase in AdaptMeas is 1.46 for *never* having heat-related health issues vs. having *frequently* heat-related health issues. The relative risk ratio for one-unit increase in the variable MHR is 0.81 for *Occasionally* having heat-related health issues vs. having *frequently* heat-related health issues. For the other predictor, the relative risk for one-unit increase in AdaptMeas is 1.28 for *Occasionally* having heat-related health issues vs. having *frequently* heat-related health issues.

4.9 Sand and dust prevention and comfort

The seventh hypothesis argues that incorporating features to prevent sand and dust intrusion into homes contributes to a more comfortable and clean-living environment, particularly in desert regions. The variable SandDust measures the incorporation of these features, with more than 65% of the sample reporting they have implemented such measures. Comfort and heat resilience are measured by the variable HIH, which includes increasing green spaces and planting more trees, implementing cool roofing technologies, and promoting water-efficient landscaping. According to Table 4-G, a linear model shows that comfort is significantly lower for those who did not incorporate sand and dust prevention features, with a difference of 0.38 units of HIH compared to those who did. The linear regression Equation 9 for hypothesis H7 can be expressed as follows:

$$HIH = 4.27 - 0.38\,SandDust \quad (9)$$

Where:

- HIH represents the comfort and heat resilience variable.
- SandDust indicates whether homes have measures to prevent sand and dust intrusion, ensuring cleanliness and comfort.

4.10 Solar panel adoption and heat perception

The eighth hypothesis posits that the installation of solar panels for solar power generation is influenced by factors such as heat perception and the desire to reduce energy costs. Using a chi-square independence test, it was found that the variables SOLAR

TABLE 7 Comprehensive analysis of multinomial logistic regression: impact and odds ratios for MHR and AdaptMeas on heat-related health issues.

Frequency	(Intercept)	MHR	AdaptMeas
A: Multinomial Logistic Regression Examining the Impact of MHR and AdaptMeas on Heat-Related Health Issues			
Never	2.3707	−4.753907***	2.8677***
Occasionally	3.3785	−2.397701**	2.1649***
B: Odds Ratios from Multinomial Logistic Regression for Predictors MHR and AdaptMeas Across Varying Frequencies of Heat-Related Health Issues			
Never	2.5343	0.5930	1.4458
Occasionally	3.1742	0.8053	1.2764

Note: Significance levels are indicated as follows: ***p < 0.001; **p < 0.01.

and the desire to reduce energy costs are dependent (p-value = 0.000). Moreover, a logistic regression model was used to test the effect of heat perception on the likelihood of installing solar panels. The results indicate that for each unit increase in the perception of unpleasantness, the odds of installing solar panels decrease by 28% (1 - exp(0.326)), as shown in Table 4-H. The logistic regression Equation 10 for hypothesis H8, which examines the influence of heat perception on the likelihood of installing solar panels, can be written as follows:

$$ln\left(\frac{P(SOLAR=1)}{1-P(SOLAR=1)}\right) = 2.605 - 0.326\,Perception \qquad (10)$$

Where:

- P(SOLAR = 1) represents the probability of installing solar panels.
- Perception is the variable indicating the level of heat perception.

5 Discussion

5.1 Interpretation of key findings in context

This study provides empirical evidence on the multifaceted nature of climate adaptation in residential communities within the UAE, offering novel insights by integrating climatic, socio-economic, and behavioral data. The negative correlation between perceived thermal discomfort and the adoption of climate-responsive technologies confirms that experiential factors drive behavioral responses to environmental stressors. These findings align with the literature on risk perception and environmental action (Semenza et al., 2008; Spence et al., 2011), highlighting the role of heat exposure as a determinant of adaptive behavior.

Moreover, the positive association between climate awareness and the implementation of sustainable practices highlights the critical role of environmental knowledge and public awareness. This is consistent with the work of Khatibi et al. (2021) and Lenzholzer et al. (2020), who emphasize that awareness is a foundational prerequisite for community-level adaptation.

5.2 Comparative analysis and contribution to existing research

While global studies have established the relevance of socio-economic status in shaping adaptation behavior (Mugi-Ngenga et al., 2016; Ndamani and Watanabe, 2016), this study adds specificity to the Middle Eastern context by demonstrating that income and education in the UAE significantly influence the adoption of both mitigation and adaptation measures. Notably, respondents with higher educational attainment and income levels demonstrated increased engagement with climate-responsive technologies, including solar panel installation and passive cooling techniques.

In contrast to findings in some Western contexts—such as van Kasteren (2014), where awareness did not necessarily result in behavioral change—our results indicate a more direct relationship between awareness and action in the UAE. This may be attributed to national sustainability campaigns and broader environmental discourse promoted by government-led initiatives such as the UAE Energy Strategy 2050 and Masdar's urban sustainability projects.

Furthermore, motivations for adopting technologies were strongly influenced by energy cost concerns and health considerations, mirroring findings by Shakeel and Rajala (2020) and Hernández (2016). Notably, this study also demonstrates that comfort-enhancing features—such as sand and dust prevention measures—play a significant role in influencing adoption behavior, a factor that is comparatively underexplored in non-desert settings.

5.3 Barriers to climate technology adoption

Despite high awareness levels, several barriers to the widespread adoption of climate adaptation technologies persist. Data derived from the survey (Q28) suggest that financial constraints remain the most frequently cited obstacle, reaffirming findings by Faiers and Neame (2006) and Nieuwenhout et al. (2001). High upfront costs for systems such as solar panels or green roofs, combined with long return-on-investment periods, discourage lower-income households from adopting these measures.

In addition to cost, perceived inefficacy of certain technologies—particularly passive systems—was cited, indicating a gap between awareness and trust in technological solutions. Sociocultural norms and aesthetic preferences may also discourage adoption, particularly in the context of modern architectural trends that prioritize appearance over environmental performance.

Policy-related barriers also emerged, particularly in the form of limited governmental subsidies and inadequate regulatory incentives. Unlike regions such as Germany or Australia where policy frameworks significantly strengthen residential solar adoption (Wittenberg and Matthies, 2016; Zander et al., 2019), the UAE's incentive mechanisms remain limited in reach and scale.

5.4 Socio-economic and cultural influences on adaptation

The intersection of socio-economic status, cultural context, and environmental perception strongly shapes climate adaptation behavior. Households with larger family sizes and villa-style residences—typically indicators of higher socio-economic standing—exhibited higher rates of technology adoption and sustainable landscaping practices. Conversely, households in older or shared units reported fewer adaptation measures, revealing structural inequality in climate resilience capacity.

Furthermore, cultural familiarity with traditional cooling methods, such as shaded courtyards or wind towers, persists. While these may be effective, they are often underutilized in modern residential construction. The promotion of culturally resonant yet technologically enhanced adaptation solutions may therefore bridge this gap, encouraging broader community participation.

5.5 Policy and planning implications

The findings of this study suggest several key implications for policymakers, planners, and urban sustainability practitioners:

- Tiered financial incentives and subsidies should be introduced to enable low- and middle-income households to adopt energy-efficient technologies.
- Building codes and urban planning regulations should mandate the integration of passive cooling strategies, particularly in new residential developments.
- Public awareness campaigns must not only raise climate literacy but also demonstrate the tangible benefits and reliability of adaptation technologies.
- Community-based initiatives, such as participatory planning workshops, can help increase local engagement and ensure that solutions are context-specific and inclusive.

Given the region's climate vulnerability, these actions are essential to building residential resilience and meeting national sustainability goals.

5.6 Study limitations and directions for future research

This study has several limitations that should be acknowledged. The use of a convenience sampling method limits generalisability, with responses concentrated in Abu Dhabi and Ras Al Khaimah. As such, findings may not fully represent communities across all Emirates or capture the experiences of underrepresented groups, such as low-income renters or those in high-density housing.

The reliance on self-reported data also introduces potential biases, including recall inaccuracies and social desirability effects. Although the sample size (n = 550) supports statistical analysis, a more representative and diverse sample would strengthen external validity.

6 Conclusion

This study provides important insights into the relationship between climate trends, public perception, and adaptation behaviors within UAE residential communities. The analysis of temperature data reveals clear seasonal variation and long-term warming projections, which are already influencing household-level decisions. As thermal discomfort increases, residents are more likely to adopt climate-responsive technologies, indicating that personal experience with heat plays a central role in motivating adaptive behavior.

The findings further emphasize the significance of community awareness and socio-economic factors—particularly income and education—in shaping the uptake of sustainable practices. Households with higher educational attainment and financial capacity are more inclined to implement both passive and active adaptation measures. In addition, exposure to heat-related health issues emerged as a strong predictor of technology adoption, highlighting the potential of health-focused messaging to drive climate resilience at the community level. Measures such as planting shade trees, using light-colored roofing, implementing blackout curtains, and incorporating sand and dust prevention were found to enhance comfort and thermal resilience, especially in the UAE's desert environment.

Beyond household-level factors, the study also illustrates the influence of economic motivations—such as reducing energy costs—on behaviors like solar panel installation. These findings point to several key areas where targeted interventions can strengthen adaptation, including the development of financial incentives, the integration of adaptive design features in building regulations, and the promotion of community education programs.

In terms of long-term implications, this research supports the need for more inclusive and localized climate adaptation policies in the UAE. As urbanization accelerates and climate risks intensify, residential adaptation will be essential for achieving national sustainability goals. The study's findings can inform future policy decisions by providing evidence on the social, economic, and perceptual drivers of adaptation. Strategies such as subsidized adoption of energy-efficient technologies, climate-responsive urban planning, and awareness programs tailored to vulnerable groups will be crucial.

Despite the study's contributions, several limitations must be acknowledged. The use of a convenience sampling method—while appropriate for exploratory research—limits the ability to generalize findings to the entire UAE population. As participation was based on accessibility rather than random selection, certain segments of the population (e.g., lower-income or rural households) may be underrepresented. Additionally, while key socio-economic variables such as income, education, and housing type were included, other potentially influential factors—such as employment sector, cultural beliefs, housing tenure, and access to public services—were not assessed and may warrant further investigation. Future research should investigate the impact of government policies—such as subsidies, tax incentives, and public information campaigns—on accelerating technology adoption and behavior change. There is also potential for exploring the use of smart technologies and innovative materials to enhance residential climate resilience. Longitudinal studies could further clarify the lasting health and behavioral effects of rising temperatures, while expanded research across different Emirates would improve the generalizability of results.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by UAEU Social Sciences Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

KA: Methodology, Investigation, Conceptualization, Writing – review and editing, Supervision, Resources, Writing – original draft, Project administration, Funding acquisition, Data curation. CB: Conceptualization, Visualization, Validation, Formal Analysis, Software, Methodology, Investigation, Writing – original draft. SS: Writing – original draft, Methodology, Conceptualization, Investigation. SA: Software, Writing – original draft, Methodology, Visualization.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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