

Role of User Experience in Designing Human Settlements for Composite Climate

Chetan Verma^{1,*}, Tanaya Verma², Alok Ranjan³

Abstract

Integrated settlements designed in a composite climate, characterized by vast variations in temperature, humidity, and seasonal extremes require the need to consider both the environment and the people. As end-users, through user experience (UX) practices, it is always possible to improve the liveability and sustainability of such settlements. In this research, a questionnaire that aims at gathering user insights on how to design human settlements for composite climates is applied to assess the role of UX in such design. The answers to the questionnaire reveal the significant user-centered elements that could be useful to architects, planners, and policymakers in creating a more flexible, more adaptive, and more comfortable environment. The research implements a set of surveys and questionnaires aimed at assessing various issues of user interaction with the built environment in composite climates. Attention is paid to thermal comfort, organization of spatial structures, daylighting, air circulation, and greenery. The analysis of the responses made it possible to identify problems and discomforts users experienced and their responses to changes in perception with seasons. Furthermore, the research investigates the connection between the features of social areas, architectural design, and use, and general health and community activity. The research emphasizes the need to fuse the related processes of the planning of settlements together with the fundamentals of climate-responsive design. Particularly, the research underlines the need to implement participatory design processes because of the intense focus on the end-users and their experience that sustainably orient changes in the forms in which composite systems exist. This paper adds to the newly emerging area of climate-responsive architecture by showing how research methods in UX like questionnaires can contribute to the important data needed to develop people's settlements in a more climate-responsive manner.

Keywords: User experience (UX), human settlements, composite climate, thermal comfort, participatory design

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INTRODUCTION

Designing human settlements in composite climates is a complex task due to the significant seasonal variations typical of these areas. Composite climates feature hot summers, cold winters, and distinct transitional periods, making it crucial for built environments to adapt to changing weather patterns. In these contexts, settlements must find a balance between energy efficiency, thermal comfort, and environmental sustainability, while also considering the needs and experiences of the people living there. This research investigates the role of user experience (UX) in developing human settlements for composite climates, highlighting how a user-centered approach can improve livability and adaptability.

Traditionally associated with digital product design, UX design is increasingly recognized as an essential element in architecture and urban planning. By concentrating on how users interact with, behave in, and perceive their physical surroundings, UX design contributes to creating spaces that not only respond to climatic conditions but also enhance overall well-being. Integrating UX principles into the design of human settlements ensures that users' experiences – such as thermal comfort, spatial arrangement, and access to natural light and green areas – are prioritized in the design process. Previous studies have demonstrated that energy-efficient design has a significant effect on occupant well-being, underscoring the importance of creating settlements that are both climate-responsive and user-focused.

Effective climate-responsive design must consider how residents adapt to their surroundings throughout the year. A participatory approach, which involves collecting feedback from users through surveys and other methods, has proven to yield better results in terms of both functionality and satisfaction. This study employs a questionnaire-based method to assess the experiences of individuals living in areas with composite climates. By gathering real-world data on how people perceive and engage with their built environments, the research aims to pinpoint key design strategies that can improve comfort, adaptability, and energy efficiency.

The goal of this paper is to explore how UX design can be utilized in the development of human settlements in composite climates, where user experiences play a vital role in creating sustainable and resilient living spaces. The insights gained from user feedback will offer valuable recommendations for architects, urban planners, and policymakers striving to enhance the quality of life in these challenging environments. Ultimately, this research highlights the significance of merging UX design principles with climate-responsive architecture to develop settlements that are not only efficient but also user-friendly.

LITERATURE REVIEW

User Experience (UX) in Design

User experience (UX) design, which has its roots in human-computer interaction (HCI), has found applications across various fields, including product design, services, and more recently, architecture and urban planning. The primary aim of UX is to improve the usability, accessibility, and overall satisfaction of users by examining how people engage with space, products, or systems. A research-through-design approach can enhance the interaction between users and their environments through participatory methods, ensuring that designs align with real user needs [1]. These concepts are becoming increasingly important in architecture, where grasping how individuals experience and interact with physical spaces – like homes, public areas, and entire communities – can result in more effective and fulfilling designs.

Climate-Responsive Design

Climate-responsive design is crucial in areas where environmental factors like temperature, humidity, and solar exposure fluctuate greatly throughout the year. Passive design techniques, such as utilizing natural ventilation, solar shading, and thermal mass, can lower energy use and improve thermal comfort in buildings [2, 3]. These methods are especially important in composite climates, where extreme temperatures in both summer and winter necessitate that buildings adjust to changing conditions. Climate-responsive architecture not only focuses on regulating the internal temperature of buildings but also emphasizes designing communities that harmonize with the natural landscape and enhances the well-being of residents throughout the year.

Human Settlement Planning

Human settlement planning focuses on designing living spaces that can support large populations while providing access to vital services, resources, and community areas. Theories of urban planning highlight the significance of spatial organization, wayfinding, and human interaction in urban settings [4]. Recent research has expanded on these concepts to include sustainability and resilience in response

to environmental challenges, especially in areas vulnerable to climate extremes. This is especially important for regions with composite climates, where communities need to be flexible in adapting to changing weather patterns while ensuring social, economic, and environmental sustainability.

Composite Climate Analysis

A composite climate is characterized by a variety of climatic conditions throughout the year, marked by significant variations in temperature, humidity, and seasonal changes (Figure 1). Typically, areas with composite climates experience hot summers, cold winters, monsoon seasons, and mild transitional periods. The term “composite” reflects the diverse weather patterns in these regions, resulting in a climate that is neither strictly hot nor cold, but rather a mix of both over the year.

- *Hot Summers:* In the summer months, temperatures can rise well above 40°C in many locations, necessitating effective cooling strategies for buildings and public areas.
- *Cold Winters:* During winter, temperatures may fall below 5°C, requiring heating solutions in indoor environments to ensure comfort.
- *Monsoon or Rainy Season:* The high humidity levels during monsoon seasons can lead to issues such as mold growth, poor indoor air quality, and a greater need for ventilation.
- *Transitional Seasons (Spring and Autumn):* These times may provide milder weather, but they also pose design challenges due to fluctuating daily temperatures and the necessity for adaptable spaces that can switch between cooling and heating.

Composite climates are commonly found in regions like northern India, parts of the United States, and central China, where significant changes in temperature and humidity create unique challenges for urban and building design.

Challenges in Design

The architectural and urban design challenges in composite climates arise from the necessity for buildings and communities to adjust to seasonal extremes while ensuring thermal comfort, energy efficiency, and sustainability. The key challenges include:

- *Thermal Comfort and Energy Efficiency:* Achieving thermal comfort year-round is a complex task, as buildings must find a balance between cooling in the summer and heating in the winter. Traditional HVAC systems often result in high energy consumption, which is neither economical nor sustainable. Implementing passive design strategies, such as natural ventilation, thermal mass, and shading devices, is essential for reducing energy usage. The passive solar design, proper insulation, and effective natural ventilation can lessen reliance on mechanical systems for climate control [3].
- *Adaptive Building Materials and Techniques:* Building materials must be responsive to both heat and cold. In warmer months, reflective roofing and walls can help prevent overheating, while in colder seasons, thermal insulation is vital for keeping indoor spaces warm [2]. Stress the importance of choosing materials and construction methods that are suited to seasonal changes in composite climates.
- *Humidity Control:* Controlling humidity levels, particularly during the monsoon season, presents a distinct challenge. Elevated humidity can cause dampness, which undermines the structural integrity of buildings and affects indoor air quality. Ventilation systems must be designed to effectively manage moisture levels.
- *Urban Planning Considerations:* Urban areas should be designed to counteract the heat island effect in summer by incorporating green spaces, water features, and reflective materials to help lower temperatures. In the winter months, communities need to shield residents from cold winds using windbreaks and thoughtful building placements. The arrangement of streets and public areas should be oriented with the sun’s path to maximize natural light during winter while providing shade in the summer. Bioclimatic principles can be integrated into urban designs for lasting sustainability in diverse climates [5].
- *Water Management:* The monsoon season presents significant challenges for water management,

making it essential to have effective drainage systems to avoid flooding and water accumulation. On the other hand, implementing water conservation methods, such as rainwater harvesting, is vital to cope with the dry summer conditions.

- *Health and Well-being*: It's essential to ensure that indoor environments provide good air quality and thermal comfort for the health and productivity of occupants. Research indicates that poorly designed spaces in mixed climates can lead to problems like heat stress in the summer and cold stress in the winter, adversely affecting both physical health and overall well-being.

Tackling these challenges calls for a comprehensive approach to settlement design that combines passive strategies, innovative materials, and a focus on user-centered design. By integrating user feedback into the design process, as discussed in this research, settlements can more effectively respond to the ever-changing conditions of composite climates, promoting comfort and sustainability year-round.

Climate-Responsive Architecture

The theoretical framework of climate-responsive architecture plays a crucial role in this study. It focuses on adapting built environments to suit local climatic conditions by employing passive design strategies like orientation, shading, and ventilation to improve energy efficiency and comfort. The concepts, such as the groundwork for understanding how designs can help settlements cope with extreme weather [3, 5]. In areas with composite climates, where temperature changes can be quite pronounced, this framework encourages the creation of settlements that reduce dependence on mechanical heating and cooling by utilizing natural resources.

Human-Centered Design (HCD)

Human-centered design (HCD) serves as a crucial theoretical framework in this research. HCD emphasizes understanding the needs, behaviors, and preferences of users throughout the design process [6]. When applied to architecture and urban planning, this approach ensures that space is not only functional and efficient but also resonates with the ways people live, work, and interact. The principles of HCD will inform the questionnaire-based methodology in this study, enabling users to share their insights on how climate-responsive design features influence their daily experiences in settlements characterized by composite climates.

Participatory Design

Building on the HCD framework, participatory design emphasizes the importance of involving users directly in the design process. This method ensures that the needs and preferences of end-users are considered from the very beginning, resulting in more effective and user-friendly solutions. In the realm of human settlements, participatory design plays a vital role in understanding how residents perceive and engage with their surroundings, especially in areas facing extreme and variable climatic conditions. By including users in the design of these settlements, the research seeks to pinpoint specific design features that can enhance comfort, adaptability, and overall satisfaction.

RESEARCH GAP

While UX design has been widely utilized in digital products and services, its application to the design of physical spaces, especially in the realm of climate-responsive architecture, is still in its early stages. Although there has been considerable research on climate-responsive strategies for buildings, the incorporation of UX principles into these designs – particularly regarding how users interact with their environments has not been thoroughly examined [7]. Additionally, while research on human settlement planning often focuses on large-scale urban development, it seldom considers how individual user experiences within these areas are influenced by both the design of the space and the local climate. There exists a research gap at the intersection of UX design, climate-responsive architecture, and settlement planning. Specifically, exploring user-centered approaches to enhance the adaptability and livability of human settlements in diverse climates is an area that deserves more attention.

METHODOLOGY

This research paper uses a mixed-methods approach to investigate the importance of user experience (UX) in the design of human settlements in diverse climates. The methodology integrates both qualitative and quantitative techniques to collect data on user preferences, climatic challenges, and design strategies that improve livability in these areas. The approach is structured into two primary phases: a literature review and survey-based research. Each phase addresses different elements of how UX can guide climate-responsive design in human settlements [8].

The literature review establishes a theoretical framework for understanding how user-centered approaches can shape design strategies that tackle the challenges posed by composite climates. A selection of key academic papers, government reports, and case studies is examined to pinpoint research gaps at the intersection of user experience (UX) and climate-specific settlement design. Additionally, the research centers on a questionnaire-based survey to collect primary data regarding user experiences and preferences in composite climates [9]. This survey is distributed to residents, architects, and urban planners in various cities having composite climate as per ECBC, with a focus on how climate-responsive design affects their daily lives and overall well-being. The survey includes questions about thermal comfort preferences across different seasons, perceptions of building materials (like insulation and thermal mass) and their effects on indoor comfort, feedback on urban planning elements, such as green spaces, water management, and public areas, as well as user satisfaction with passive cooling and heating strategies (including natural ventilation and shading devices). It also explores their overall experiences with climate-responsive design, highlighting challenges faced and suggestions for improvement.

DATA ANALYSIS

Each question is tailored to extract data related to user comfort, design challenges, climate-responsive strategies, or adaptation behaviors. The responses will provide insights for refining settlement designs, improving energy efficiency, and enhancing user comfort through a more climate-adaptive and user-centered design approach (Table 1).

Table 1. Mapping of research objectives with research questionnaire.

Question	Objective	Expected Outcome
How long have you been living in a settlement located in a composite climate?	Understand user adaptation strategies over time in composite climates	Insights into how long-term exposure to composite climates affect perceptions of comfort and settlement adaptation.
How frequently do you need to use artificial heating or cooling systems in your home to maintain comfort during extreme temperatures?		Insights into the reliance on artificial climate control, informing energy-efficient design solutions.
How would you rate your overall comfort in your home during the summer season?	Assess user comfort and satisfaction	Identification of specific issues with thermal comfort during summer months to guide future design improvements.
How would you rate your overall comfort in your home during the winter season?		Determine how well homes are suited for winter conditions, leading to recommendations for insulation and heating improvements.
How satisfied are you with the amount of natural light in your living space throughout the year?	Evaluate user satisfaction with design features and their impact on comfort	Evaluation of the sufficiency of natural light and suggestions for design features that maximize daylighting.
How satisfied are you with the spatial arrangement (room layouts, positioning of windows, etc.) of your home in terms of maximizing comfort during different seasons?		Identification of user satisfaction with spatial design, leading to better room layout strategies that enhance comfort across seasons.
How often do you use communal or outdoor spaces in your settlement during extreme weather conditions (e.g., summer heat or winter cold)?		Understand how outdoor spaces are used in extreme weather, leading to design solutions for year-round outdoor comfort.

How important is natural ventilation (airflow) in your living space for your comfort?	Evaluate climate-responsive design features	Gather feedback on the importance of natural ventilation, leading to potential enhancements in airflow designs.
During seasonal transitions (spring/autumn), how well does your home maintain comfortable indoor temperatures without additional heating or cooling?		Identify areas where homes perform well or poorly during transitional periods, informing passive design strategies.
How does the design of your settlement (e.g., street layout, orientation of buildings) contribute to or hinder natural ventilation and cooling during hot seasons?		Insights into how urban layout affects natural cooling, informing better street and building orientation strategies.
How energy-efficient do you perceive your home to be, considering the need for heating, cooling, and other energy-consuming adjustments in response to climate conditions?		Gather user perceptions on energy efficiency, leading to recommendations for reducing energy use through improved design.
How would you rate the insulation quality of your home in managing temperature extremes?	Identify key design challenges	Feedback on insulation performance, leading to improvements in material choices and thermal management strategies.
Do you think the design of public spaces in your settlement (e.g., parks, open areas) supports comfortable use throughout the year in a composite climate?		Assess whether public spaces are adaptable for year-round use, leading to urban design improvements for public comfort.
Do you feel that your home provides enough flexibility in design (such as movable walls, and open plans) to adapt to varying seasonal needs?	Generate user-centric design insights	Determine if flexibility in design is sufficient, informing future adaptive and modular design features for seasonal adaptability.
How would you rate the overall adaptability of your settlement to the diverse weather patterns experienced in a composite climate?		Determine settlement adaptability and propose changes to improve resilience to the varying weather conditions of composite climates.

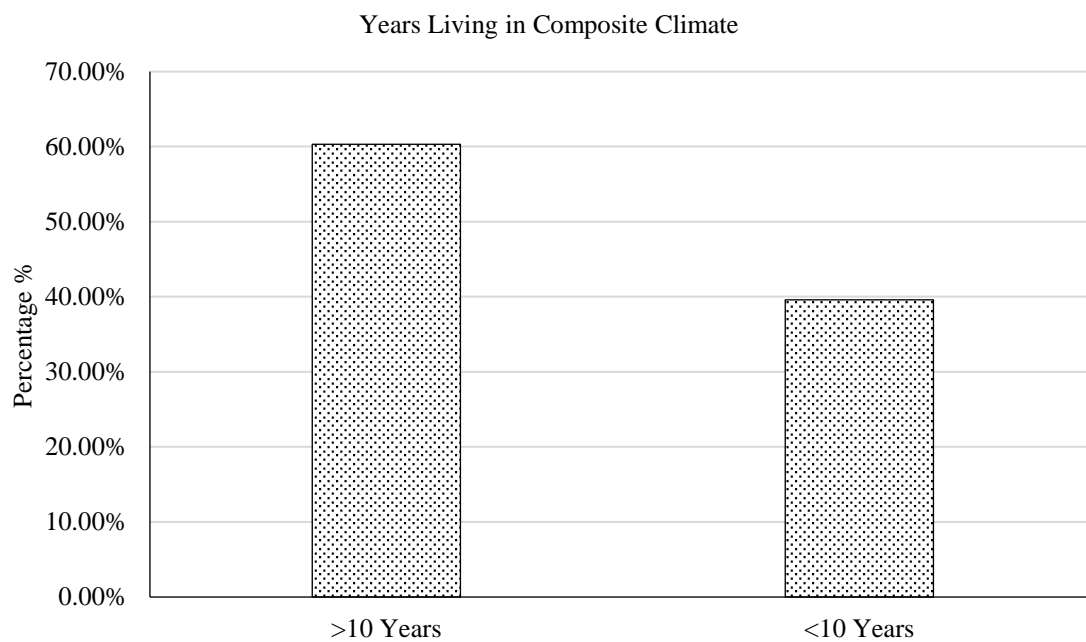


Figure 1. Respondent’s years living in composite climate.

In total 58 responses were received from 3 states, 2 union territories, and 3 cities classified in composite climate by energy conservation building code (ECBC). The age of maximum number of

respondents lies between 23–49 years. 60.3% of respondents were male and 39.6 of respondents were females. Data collected have 81% of respondents living in urban areas. Also, 62.1% of respondents have been living in a composite climate for more than 10 years.

FINDINGS

A significant number of respondents (62.1%) have resided in a composite climate for over 10 years, highlighting that many individuals have considerable experience in adjusting to their local climate (Figure 2). The feedback reveals a strong dependence on artificial systems, with 62.1% of participants stating they “always” or “often” utilize heating or cooling systems to stay comfortable during extreme weather. This indicates that even after many years in the climate, numerous residents still struggle to adapt without mechanical assistance [10]. The heavy reliance on these systems implies that homes might be lacking effective passive climate-responsive features, such as natural ventilation, thermal mass, and shading. Enhancements in these areas could lessen the necessity for artificial heating and cooling.

A greater number of respondents report feeling comfortable in winter (58.7% choosing “comfortable” or “very comfortable”) compared to summer (36.2%). This indicates that winter conditions are generally easier to manage in terms of comfort, while summer poses more difficulties (Figure 3). Discomfort levels are notably higher in summer, with 63.8% of respondents experiencing some degree of discomfort (“very uncomfortable,” “uncomfortable,” or “somewhat uncomfortable”) versus 41.3% in winter. Most respondents expressed satisfaction with the natural light in their homes, with 69% rating it as “satisfied” or “very satisfied.” A small fraction (12%) report dissatisfaction, suggesting that natural light is typically well-considered in home design. Satisfaction regarding the layout of homes is also high, with 60.4% rating it as “satisfied” or “very satisfied.” However, 39.6% indicate some level of dissatisfaction, highlighting potential areas for improvement in optimizing room layouts and window placements for seasonal comfort. While 31% of respondents utilize communal or outdoor spaces “very often” or “often” during extreme weather, a notable portion (37.9%) only uses them “sometimes,” and 29.3% use them “rarely.” This suggests that extreme weather conditions may restrict the use of outdoor areas, emphasizing the need for better climate-responsive public space design.

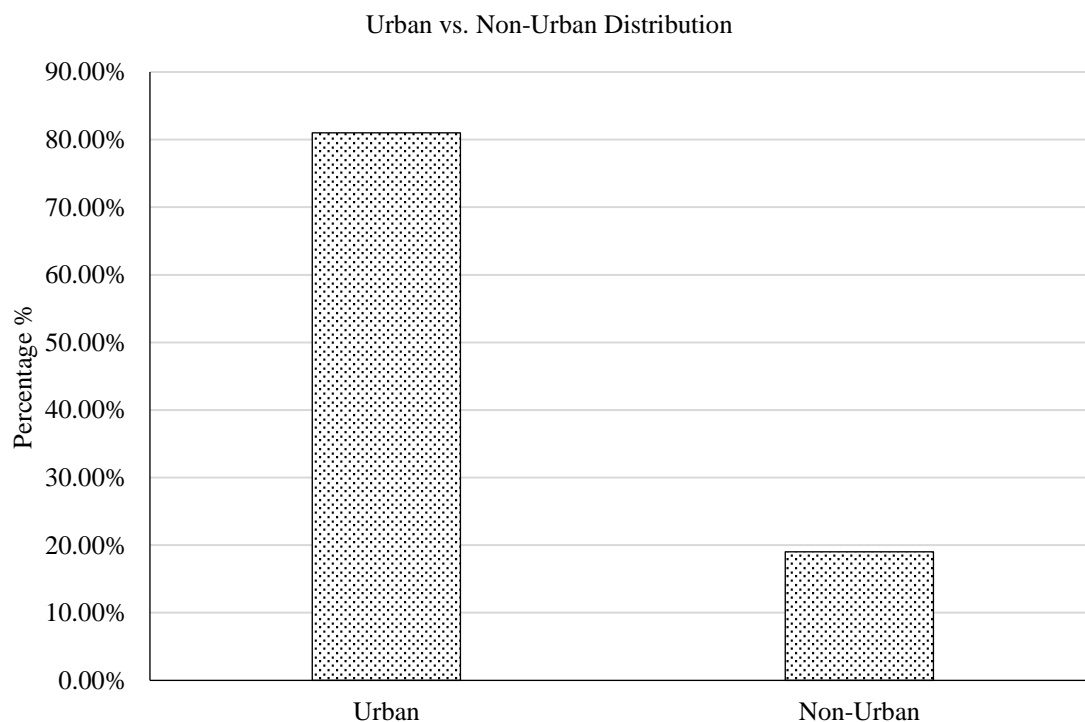


Figure 2. Respondents living in urban and non-urban areas.

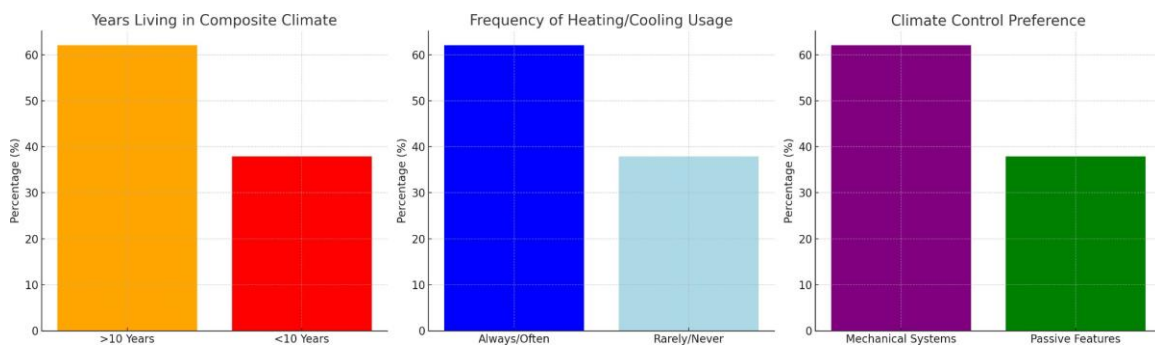


Figure 3. Climate experience and system usage analysis.

The significant emphasis on natural ventilation, with 91.3% of respondents rating it as “important” or “very important,” indicates that settlement designs should focus on enhancing airflow through strategic window placement, building orientation, and street layout. While many respondents feel their homes perform adequately during transitional seasons, nearly half report experiencing less-than-ideal conditions. Enhancing insulation and utilizing passive temperature control methods could improve overall comfort. Although most participants believe their settlement design supports natural ventilation, a small yet noteworthy percentage (13.8%) feel it either “somewhat hinders” or “significantly hinders” airflow. This points to the necessity for further improvements in urban design. The mixed views on energy efficiency suggest a need for more uniform and effective energy-saving strategies across settlements. Raising awareness about energy-efficient practices and using energy-efficient materials can help address this issue.

The findings emphasize the necessity for improved insulation in homes to cope with the temperature fluctuations typically in composite climates. The fact that almost 28% of respondents describe their insulation quality as “poor” or “very poor” indicates that numerous buildings may lack sufficient thermal protection, resulting in higher energy usage for heating and cooling. While nearly half of the respondents believe that public spaces are well-designed for year-round use, the other participants point out limitations or inadequacies. This implies that many outdoor areas may not include features that accommodate seasonal changes, such as shaded spots for summer or sheltered areas for winter.

The high percentage of respondents who view their homes as inflexible indicates that current designs might not sufficiently accommodate user adjustments for seasonal changes. Incorporating features that enable spatial modifications, such as movable partitions, multi-functional areas, and open floor plans, could be more effectively utilized to improve comfort. The general perception of communities being “slightly adaptable” or “unadaptable” highlights the necessity for a more climate-responsive strategy in settlement design. This could include elements like street orientations that enhance natural airflow, seasonal landscaping, and materials that adapt well to temperature changes.

CONCLUSIONS

The data shows a considerable dependence on artificial heating and cooling in different lengths of stay within mixed climates. Although some long-term residents might have found effective ways to adapt, there is still a substantial chance to enhance passive design elements and encourage sustainable behavioral changes. The survey results also indicate that there is a bigger challenge in keeping comfortable during the summer. They also point out specific areas where design improvements could greatly boost user satisfaction, like optimizing spatial layouts and enhancing the usability of outdoor spaces. The findings highlight the importance of natural ventilation, temperature control, and energy efficiency in climate-responsive design for mixed climates. Improving these elements can greatly enhance user comfort and satisfaction. The quality of insulation and the design of public spaces pose considerable challenges in composite climates. Tackling these issues can enhance the livability and comfort of communities, making them more resilient to the diverse conditions typical of this climate type. The data also reveals notable shortcomings in the flexibility of home designs and the overall

adaptability of communities to diverse climates. By focusing on user-centered design enhancements, we can create more livable and climate-resilient spaces, ultimately improving user satisfaction and comfort year-round.

Further Discussion

The survey underscores the importance of user-centered design in composite climates, where a heavy dependence on artificial heating and cooling reveals shortcomings in passive features. By improving natural ventilation, insulation, and climate-responsive layouts, we can lessen this reliance and promote sustainable living. Summer discomfort has surfaced as a significant concern, suggesting that existing architectural solutions do not adequately tackle heat-related challenges. Enhancements focused on cooling, such as better building orientation, shading, and heat-reflective materials, along with improved usability of outdoor spaces, could boost comfort and encourage year-round use.

Focusing on temperature control and energy efficiency is essential. Enhanced insulation and thoughtfully designed layouts for cross-ventilation can lead to greater indoor comfort while reducing energy consumption. The limited flexibility in home designs indicates a need for adaptable features, such as modular layouts or multi-functional spaces, to better accommodate seasonal variations. In the end, incorporating climate-resilient and user-focused design can foster more livable, adaptable, and sustainable communities, ultimately improving the quality of life for residents.

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