ANALYZING LIVING CULTURE AND CLIMATERESPONSIVE VERNACULAR ARCHITECTURE IN KERALA

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Abstract. Kerala, an Indian state in the southwest, is well known for the rich cultural legacy that is deeply ingrained in its traditional architecture. The vernacular architecture of Kerala is examined in this dissertation, with an emphasis on how it relates to the local culture and adapts to the tropical environment.
Kerala's traditional architecture is an important role model for sustainable construction methods since it balances culture, climate responsiveness, and sustainability. Kerala's vernacular architecture has been shaped by historical evolution, indigenous design principles, and building techniques, all of which are critically examined in this research. It also explores the socio-cultural elements that shape architectural decisions, showing how these constructions have changed throughout millennia to represent the fluidity of civilization. Additionally, this study examines the climate-responsive elements found in Kerala's traditional architecture, which were created to fend off harsh summers, prolonged monsoons, and elevated humidity levels. Using materials that are acquired locally, cross-ventilation, raised plinths, and fine timber workmanship are some strategies. This research investigates the suitability of Kerala's traditional architectural principles to produce climate-responsive, sustainable structures in the context of current environmental issues. The state has a tropical climate with strong monsoons, sweltering summers, and coastal areas that are vulnerable. Through a thorough analysis of case studies and environmental evaluations, the research demonstrates how ancient strategies may be adapted to current building to lower energy usage and the carbon impact. The social and economic implications of sustainable construction methods in Kerala vernacular architecture are also covered in this research. In the end, this research offers a comprehensive knowledge of Kerala's traditional architecture, acknowledging both its cultural importance and its capacity to tackle urgent sustainability and climate change challenges. It seeks to provide inspiration for global architects, urban planners, and policymakers by utilizing Kerala's rich architectural legacy to produce constructed environments that are sustainable and deeply ingrained in the local culture.

Keywords: Vernacular architecture, traditional building methods, energy efficiency, local materials, and reducing carbon footprint in response to climate change.

1. Introduction

(Yang, 2016) Due to the region's advantageous location along historic trade routes, Arab, Chinese, Portuguese, Dutch, and British civilizations were among those with whom ideas, influences, and architectural styles were easily exchanged. This blending of many inspirations and native customs has produced a distinct architectural style that exemplifies a marriage of innovation and tradition. This study explores the ways that Kerala's vernacular architecture reflects the socioeconomic, religious, and historical aspects of the local society while attempting to peel back the layers of cultural identity that are entrenched in the buildings. Every architectural manifestation—from the striking temple complexes to the recognizable backwater settlements—testifies to the dynamic interaction between cultural manifestations and the constructed environment.

Kerala's vernacular architecture is becoming more and more significant in terms of climate-responsive design as the state struggles with the effects of climate change. The state has a tropical environment with strong monsoons, hot summers, and coastal areas that are vulnerable. The target of such study is to verify how Kerala's traditional architectural methods have changed over centuries in response to these climate-related difficulties. The project intends to glean important insights into the sustainable benefits of Kerala's vernacular architecture by closely examining the usage of materials and passive design strategies. This will serve as a model for modern architects and policymakers who are tackling climate-responsive design. This study article, which unravels the complex web of Kerala's living culture woven into the fabric of its vernacular architecture, essentially acts as a bridge between the past and the future. (B, 2017)

2. CLIMATE-RESPONSIVE VERNACULAR ARCHITECTURE IN KERALA?

The term "climate-responsive vernacular architecture" describes how customary construction techniques and architectural forms have changed throughout time in certain areas to adapt to the local climate and environmental factors. It is a style of architecture that is firmly anchored in the geographical and cultural context of a certain place, taking into account the particular climate difficulties that its residents experience. The capacity of climate-responsive vernacular architecture to promote occupant comfort and well-being via the use of natural resources and climatic adaptation is its primary attribute. Energy efficiency, ventilation, and temperature regulation are maximized via the use of regionally specific materials, building methods, and design concepts in this type of architecture. (Jagatramka, 2020)

For instance, vernacular architecture may have courtyard patterns to encourage natural ventilation, thick walls for thermal mass and tiny windows to reduce heat input in hot and dry climates. On the other hand, areas that receive a lot of rain may choose to build tall buildings, steep roofs, and efficient drainage systems to avoid floods. Climate-responsive vernacular architecture is essentially a sustainable strategy that utilizes local knowledge and customs to build buildings that are both naturally attuned to the environment and culturally significant, encouraging resilience and mitigating the built environment's negative effects on the surrounding ecology.

Aspect of Analysis	Description	Relevance to Research Objective
Geographical Context	Kerala's terrain, geographical location on India's southwest coast, and how these elements affect the region's varied climatic patterns.	An essential resource for comprehending how Kerala's environmental background shapes architectural decisions and cultural customs
Cultural Influences	examination of how Kerala's living culture has been shaped historically, religiously, and socioeconomically and how these influences have been reflected in the region's vernacular architectural styles.	Fundamental to uncovering the cultural significance of architecture and its role in reflecting the identity of the community.
Architectural Features	Key architectural elements seen in Kerala's vernacular architecture, such as spatial organization, building materials, and construction methods, are identified and analyzed.	Core in assessing the physical attributes that contribute to the climate responsiveness and cultural relevance of architectural designs.
Climate Challenges	Examination of the specific climate challenges faced by Kerala, including monsoons, heat, and coastal vulnerabilities, and how these challenges influence architectural design.	Crucial for understanding the driving forces behind the development of climate-responsive strategies for vernacular architecture.
Adaptive Strategies	Examining Kerala's vernacular architecture's use of traditional adaptable measures, such as natural ventilation, passive design, and shading techniques.	Key in analysing how architectural practices in Kerala have evolved to address climate challenges and promote sustainability
Sustainability Impact	Evaluation of the sustainability aspects inherent in Kerala's vernacular architecture, considering the ecological footprint, energy efficiency, and long-term resilience of these structures.	Central to assessing the broader environmental impact of vernacular architecture and its part in promotion for sustainable living practices.
Cultural Continuity	Talk about the ways in which Kerala's vernacular architecture and living culture are entwined, examining the ways in which these buildings still fulfill social and cultural roles.	Integral in establishing a link between architectural traditions and the preservation of cultural identity, highlighting the dynamic nature of living cultures

Contemporary Relevance	Examination of the applicability of climate responsive vernacular architecture in modern times, and its relevance in the context of sustainable design practices globally	Key for understanding how traditional practices can inform contemporary architectural discourse and contribute to global sustainability initiatives

Table 1. Research Objective from Aspect of Analysis as per design

3. History and Evolution of Living Culture and Vernacular Architecture in Kerala

3.1 Historical Overview of Living Culture in Kerala

Kerala's historical overview of living culture reveals a colorful tapestry made from the strands of many influences, long-standing customs, and a dense sociocultural fabric. Kerala, a state on India's southwest coast, has a vibrant living culture that stems from long-gone indigenous customs that influenced social structures, settlement patterns, and a strong bond with the area's abundant natural resources. The blending of Vedic and Dravidian customs, characterized by ceremonies, artistic expressions, and particular social codes, produced a distinct cultural identity that flourished in the rich soil of this coastal region. Social hierarchies and the synthesis of diverse influences through trade were brought about by the feudal era, which helped to create a cosmopolitan cultural landscape. The colonial era introduced European influences and greatly enhanced Kerala's cultural mix, leaving an enduring legacy. (Dili, 2010)

A dynamic culture that has skillfully combined tradition with flexibility in response to outside influences has been fostered by festivals, the arts, culinary customs, and a strong spiritual ethos. Kerala's living culture, with its amicable coexistence of Hinduism, Islam, Christianity, and other faiths, has been a monument to religious concord over the ages. Religious buildings exhibit this harmony through their syncretic architecture, which combines aspects from several traditions. Kerala's living culture demonstrates its adaptation and durability through its communal festivals, traditional settlement patterns, and dedication to environmental sustainability. This summary of history offers a nuanced understanding of the principles that have guided the development of Kerala's unique vernacular architecture, reflecting the knowledge of a living culture intricately entwined with its past, present, and the forces of constant change.

3.2 Cultural Heritage and Traditions

Kerala's cultural legacy and traditions, which encompass a complex tapestry of tangible and intangible aspects passed down through centuries, serve as the cornerstone of the region's identity. The architectural wonders that dot the terrain, from colonial-era churches to ancient temples with elaborate carvings to traditional Nalukettu dwellings, eloquently convey tangible cultural history. These buildings tell the tale of Kerala's past by combining elements of native customs with those of traders, adventurers, and colonists. The woodwork and elaborate carvings that adorn traditional homes symbolize not only architectural skill but also the cultural knowledge ingrained in building methods and space planning. (Publication, 2020)

Oral traditions that are ingrained in daily life, religious ceremonies, and the performing arts are all rich sources of intangible cultural heritage. Kerala's cultural legacy is vividly expressed via traditional art forms like Kathakali and Mohiniyattam, which have their roots in mythology and narrative. With their customs, music, and group meals, festivals like Onam and Thrissur Pooram exemplify the intangible elements of cultural continuity and community building. A strong sense

of identification and belonging is fostered by the preservation of folktales, oral histories, and traditional languages, all of which add to the wealth of intangible cultural heritage. Kerala's living culture is made up of both tangible and intangible cultural legacy, which interact dynamically to define the region's communal consciousness.

Kerala's living culture has been greatly shaped by socioeconomic factors, which also contribute to the region's unique identity. Many aspects of daily life, such as the formation of vernacular architecture, employment practices, and settlement patterns, have been profoundly impacted by the socioeconomic landscape. Kerala has long been known for its distinct socioeconomic structure, which is typified by trade, a complicated caste system, and agricultural activities. Paddy farming, the mainstay of the agrarian economy, shaped settlement patterns, with the hierarchical social structure reflected in the "Nalukettu" architectural style. Trade, especially the spice trade, promoted cross-cultural interaction and brought in outside influences, fostering a cosmopolitan environment. (Broer, 2019)

The adaptable character of cultural activities and the syncretic design of religious structures reflect the socioeconomic diversity of the region. The socioeconomic landscape has changed throughout time, affecting community relationships and career options due to urbanization, globalization, and educational developments. The complex interactions between social norms, economic systems, and the built environment are highlighted by the socioeconomic impacts on living culture, which help to define Kerala's distinct cultural legacy. (Broer, 2019)

4. Evolution of Vernacular Architecture and Traditional Building Techniques in Kerala

Kerala's fascinating journey through the development of its vernacular architecture is a reflection of the region's enduring ties to its historical, cultural, and natural surroundings. Kerala's vernacular architecture, which has been influenced by centuries' worth of socioeconomic, religious, and climatic influences, is evidence of the creative ways in which its people have managed to blend in with the lush tropical landscape. The Nalukettu style of building, steeply slanted roofs, and the use of locally available materials like wood and laterite are characteristics of Kerala's traditional architecture. (Gupta, 2020)

The study analysed 114 vernacular places, focusing on the characteristics of vernacular architecture in various temperature zones. Key features including the envelope, ceiling, walls, bedrooms, architectural shape, height, doors, drainage, earth connection, and sheltering styles, which define regional vernacular architecture. The research assessed how such frameworks impact energy consumption how buildings are modelled and optimized. Findings suggestions that traditional dwellings having thatched roofs and mud walls are most energy-efficient compared to contemporary buildings constructed under strict energy requirements. This efficiency is attributed to the natural materials and design principles used in vernacular architecture, which are well-adapted to local climates. The study highlights the potential benefits of integrating traditional architectural elements into modern building practices to enhance energy efficiency. By examining different temperature zones, the research underscores the adaptability and sustainability of vernacular architecture. This approach offers valuable insights for designing energy-efficient buildings that align with local environmental conditions. The comparison between traditional and contemporary structures demonstrates the advantages of time-tested construction methods and materials in reducing energy consumption. Overall, the study advocates for a blend of traditional and modern techniques to achieve sustainable and energy-efficient architecture. (Gupta, 2020)

Kerala's traditional buildings use passive and natural thermal comfort techniques to handle the region's hot and humid climate. These climate-responsive features are based on Vaastu shastra, or traditional Indian architecture. Kerala experiences significant rainfall, high humidity, and moderate temperatures, with primarily two seasons: rainy and dry. This climate has led to the development of specific planning and design elements. Common features include open courtyards, sloped ceilings, and walls, and cottages at the ceiling end to enhance air circulation. Decorative nets serve as air circulation systems for basement rooms, which are often formed by dramatic timber roofs and beams. Typical materials include sludge, limestone, marble rock slabs, cement concrete, timber, and wood for masonry artwork. These elements collectively create a comfortable indoor environment by utilizing traditional architectural principles to address local climatic conditions (Dili A., 2010)

Parameter	**Climate**		
	Cold	**Hot**	**Composite**
Room Structure	Single room structure with fire pit	Single-room structure with good ventilation	Three-four rooms with or without fire pit
Building shape	South-facing, L and U shaped	East-west axes, circular, rectangular	Generally South facing and Rectangular
Courtyard	Not present	Present	Not present
Layout	Compact	Loosely packed	Partially compact
Material	Roof- slates, thatch, bark, felt, wood, turf, palm leaves	Roof- slates, thatch, bark, felt, wood, turf, palm leaves	Walls- adobe, stone, roof- wood, bamboo and slates, thatch
Building Story	Multi	Single	Double
Grills	Not used	Intricately carved in stone, wood, Translucent screens	wooden carved jalis
Construction	Massive	Lightweight	Massive

Table 2. Certain characteristics of historic buildings that make them both energy-efficient and climate-appropriate. (Widiastuti, 2015)

5. Analysis Factor for Vernacular Architecture and Traditional Building Techniques in Kerala

5.1 The Basic Form of spaces

The typical Kerala house is called a nalukettu, and it consists of four independent sections encircling a central courtyard. Their usual layouts are square or rectangular. featuring an all-inward-sloping roof, with the exception of the courtyard, which is exposed to the sky. A covered verandah surrounds the courtyard to save people from getting too wet or too much sun.

A typical Kerala home's floor design is shown in figure shown below. The courtyard and all surrounding blocks are carefully planned to adhere the specified dimensions, scale, and proportions.

Depending on the size and status of the residing family, structures may have one or more stories, or extra modules with private courtyards.

The nalukettu can be repeated to create an ettukettu, or eight-block building, or it can be

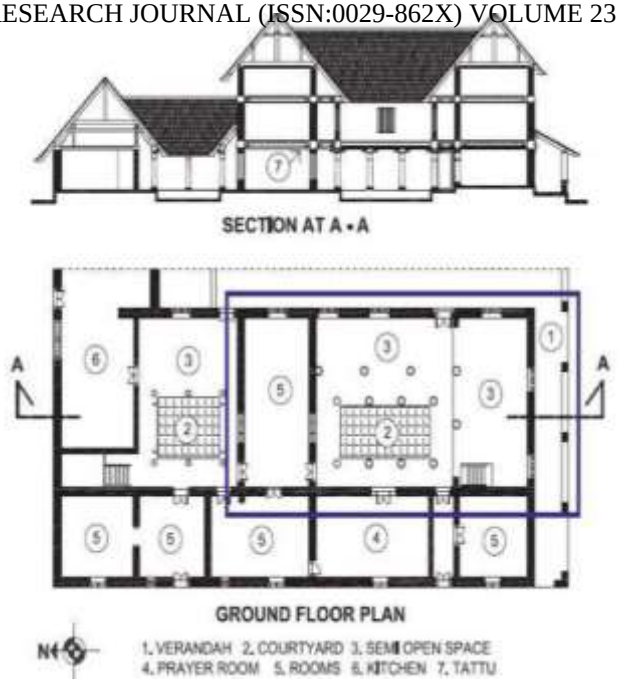

Figure 1. Plan and section view of traditional architecture

assembled into a group of related courtyards. Often, the focal point of the enclosure is the submerged courtyard. Roofs having high slopes of up to 45 degrees, and mughappu (eaves-mounted ridge vents) are placed to assist airflow and release excess heat. The verandas that open to the courtyards offer much-needed relief from the blazing sun. Moreover, an attic space is created in each room by installing a wooden fake ceiling, or "tattu," which is subsequently ventilated with exquisite jalli.

5.2 Construction Material

Traditional Kerala architecture often makes use of clay roofing tiles, wood, bamboo, mud, laterite, granite stone blocks, lime mortar and coconut palm leaves. Granite is a strong and long-lasting stone, because it is scarce outside of the highlands, its use is limiting it to the base of buildings. Laterite, which may be found at shallow depths, is a common material for building blocks in Kerala since it's affordable, easily accessible, and easy to deal with. Exposure to air merely serves to reinforce and extend its longevity. The conventional glue for laterite blocks used in traditional building is lime mortar. The outside of laterite walls are either treated with lime mortar or left unfinished. Additionally, *Eralan* architecture uses a lot of wood. A wide variety of trees and plants are utilized, ranging from teak (Tectona Grandis) to bamboo (Bambusa Oldhamii). Kerala residential architecture is characterized by its expert construction, exact joinery, thoughtful wood selection, and delicately carved columns, walls and roof frames. Traditional architecture enhances usage of variety of mud materials, including mud walls, bricks, and clay tiles for flooring and roofing. Mud mortar is utilized for laterite masonry and mud filler is utilized for wood floors. Locally sourced mud often mixed with natural admixtures to enhance its properties.

5.3 Building orientation

The four cardinal directions must be honored, as stated by Vastu , and this is rigorously adhered to in authentic Kerala architecture. The best possible comfort is possible all year round thanks to the enhanced temperature control. We can determine the cardinal directions with accuracy by using the traditional techniques that rely on the passage of the sun and shadows. Both the east

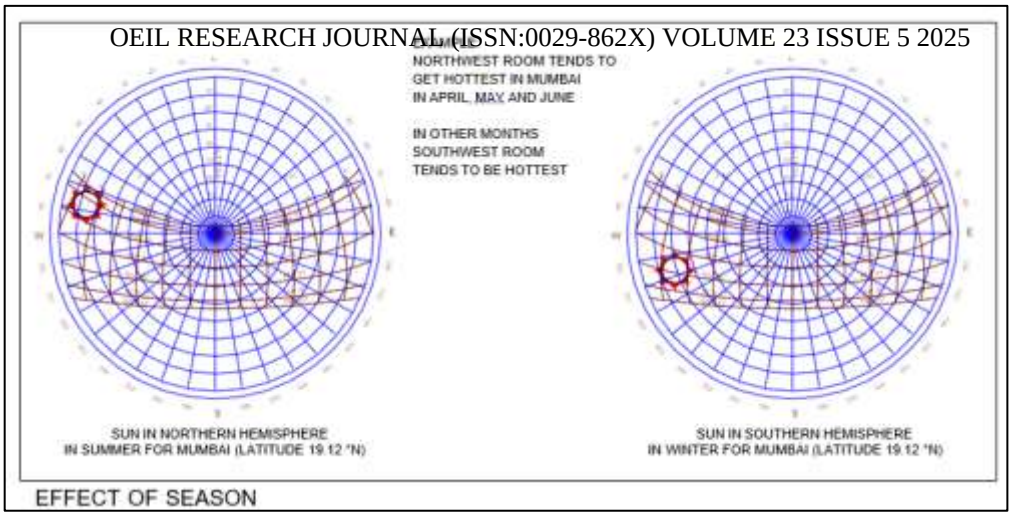

Figure 2. Sun path For Building Orientation

and the south provide entrance to the structure. Daytime activities are situated on the building's north and south faces, while night time activities were located on its west side.

5.4 Courtyard Location

Courtyards, also known as patios, are buildings that are entirely or partially enclose an open space were common in warm, humid areas. These spaces create unique microclimates that can

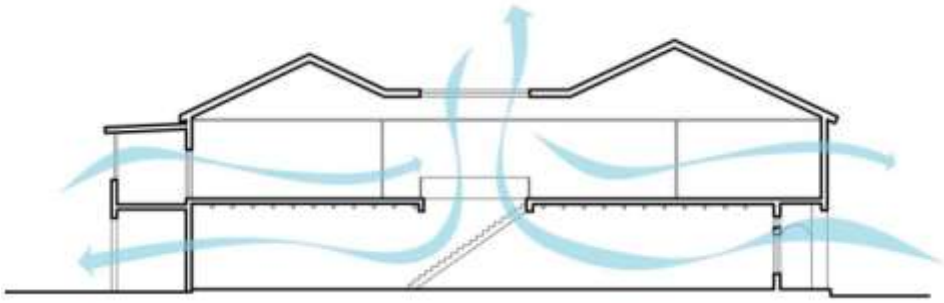

Figure 3. Air movement in traditional architecture

enhance the interior comfort of the surrounding buildings. Courtyards offers better microclimatic conditions compared to surrounding having open areas, improving thermal comfort inside the buildings. This is particularly true if there is adequate ventilation and sunlight reaches all parts of the structure. Properly designed courtyards can effectively regulate temperature and airflow, contributing to a more pleasant indoor environment.

Among its numerous advantages, the courtyard acts as a natural air conditioner. The courtyard's upper level will warm up more in the afternoon than its lower levels due to solar radiation. The air situated in uppermost part of courtyard rises and gets warmer and brighter as a consequence. As a result, as shown in Fig. 2, there is a reduction in pressure in the courtyard, which allows a breeze to enter via the open windows and doors. When dusk falls, the occurrence continues until convective movement cools the courtyard's air to a tolerable temperature. Researchers employed smoke to imitate windless circumstances in order to learn more on airflow in courtyard is affected and what that looks like effect of wind slows down. (Dili A. S., 2010)

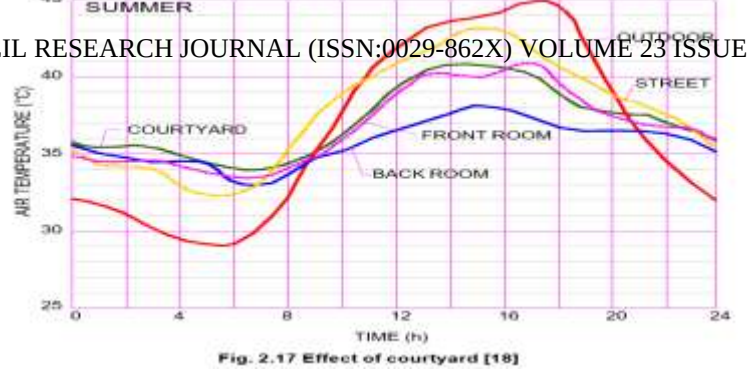

Figure 4. Temperature variation through the effect of court yard

5.5 Thermal protection

Due to materials and construction techniques employed, the walls and roofs of Kerala's vernacular buildings effectively maintain a suitable indoor temperature. The external walls of vernacular buildings were relatively thick reaching up to 750 mm, constructed using double-layer laterite masonry with fine sand-filled void in between. This design results in exceptional insulation for the exterior walls. A built timber ceiling, or tattu, serves as heat insulation beneath the roof, creating a significant amount of dead air space in an attic which prevents heat from penetrating through the ceiling. For optimal cross-ventilation, there are openings (jalli) on each side of air volume. The space between the clay tiles used on the roof surface allows for additional ventilation. This design ensures that the bottom of the roof has access to adequate airflow. Additionally, Kerala's vernacular architecture addresses thermal regulation by including perforations in the outer walls, which allow for continuous airflow from outside. These innovative design features and materials collectively contribute to the effective thermal management of interior spaces in Kerala's vernacular buildings. Such an approach not only enhances comfort but also demonstrating about how the practical application of traditional architectural principles responds to the region's climatic conditions.

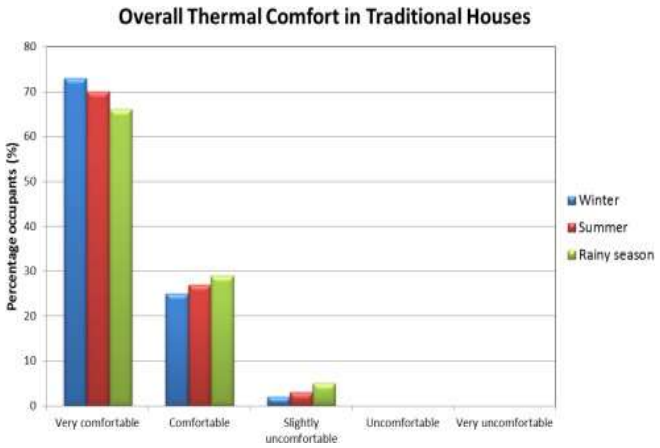

Figure 5. Seasonal Thermal Comfort in Traditional Houses

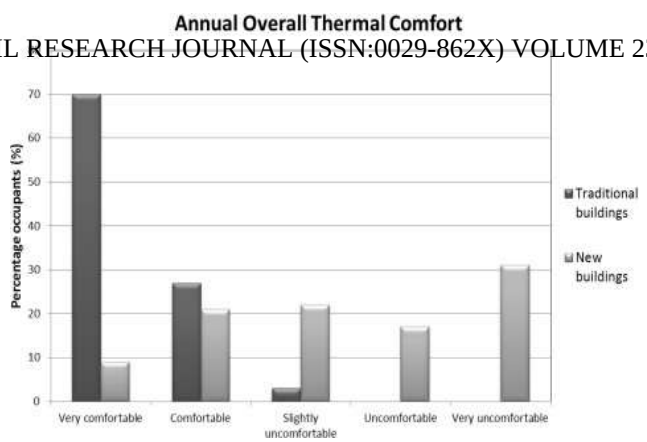

Figure 6. Annual Thermal Comfort

6. Research Findings

The objective of this particular study is helpful in conducting a statistical analysis of thermal performance and climatic responsiveness of traditional and contemporary structures in Kerala by examining existing literature. Over the course of the day, the outdoor temperature fluctuates by 12 degrees Celsius, ranging from 22 to 34 degrees. In contrast, internal temperatures remain more stable, fluctuating between 26 and 30 degrees Celsius, with only a 4-degree variation between day and night, as shown in Fig. 3.

The study finds that while the upper half of the courtyard is just slightly cooler than the outdoor temperature the bottom half of the courtyard is approximately 5 degrees celsius cooler. The verandah's temperature varies in sync with that of the upper courtyard throughout the day. At night, the semi-open space and the upper courtyard's temperatures change in tandem with the bedroom's temperature. Throughout the day, the chamber is consistently 4.8 degrees Celsius cooler than the partially exposed area outside the courtyard. Remarkably, the indoor air remains at a comfortable 26 degrees Celsius at night, even when outdoor temperature drops up to as low as 22 degrees. (Prakash, 2023)

7. Conclusion

An international overview of studies on vernacular architecture is offered in order to identify energy-efficient features that can improve indoor thermal comfort. This paper discusses how the earth is now used as a construction material, legal restrictions, and vernacular design adjustments for improving energy efficiency in modern settings. Local or traditional architecture offers solutions that blend together with the surroundings. Controlling the interior temperature has always been important to vernacular architects.

It is possible to locate tried-and-true passive management systems in older buildings all over the world, but researchers studying energy-efficient and ecologically friendly construction are presently eliminating them. A comprehensive review of Kerala's climate-responsive vernacular architecture and living culture has come to the clear conclusion that the integration of cultural practices and environmental responsiveness is a fundamental component of sustainable living. Kerala's architecture exemplifies a complex interplay between tradition and climate adaptation, which reveals both a deep grasp of the local ecology and a strong bond between the society and its constructed environment. Investigating the subtleties of vernacular architecture reveals that these buildings are living representations of a vibrant cultural legacy that has endured through the ages rather than just being tangible objects. The importance of Kerala's traditional architecture goes beyond its ability to adapt the present scenario of environment; it also acts as a guardian of social customs, cultural narratives, and collective identities.

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