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Locality values in thermal comfort embodied in Traditional Indonesian Houses: A literature review

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Abstract. This study aims to explore how traditional buildings of Indonesia adapted and respond to the current climate. Scientific publications regarding traditional houses from the various region in Indonesia were gathered to be examined the locality values in thermal comfort. The examination of the scientific publications highlighted some housing elements and arrangements that influence the thermal comfort of the houses. The building elements that affect the thermal comfort encompass lifted house on stilts; appropriate size and amount of windows; ventilated roof; selected natural material; divider arrangement; and the existence of veranda. Furthermore, as exemplified in Bali, the proper spatial arrangement between house buildings and open space also influences traditional Indonesian houses' thermal comfort. In conclusion, dealing with climate in a tropical area with high humidity can be demonstrated in those locality values without consuming excess energy for a cooling system. The significance of this study is beneficial for the development of tropical houses, which is expectedly to consider those locality values.

Keywords: locality, thermal, traditional houses, Indonesia

1. Introduction

Artificial lighting, heating, cooling, and ventilation are used heavily in modern Indonesian structures. It implies that mechanical equipment consumes more energy, which is not sustainable. Thermal comfort is a state in which a person's psychological, physiological, and behavioural patterns are at ease while they are in an environment with a specific temperature. According to theory, humans can adjust to thermal changes in three ways: behavioural pattern adaptation, physiological adaptation, and psychological adaptation. Several heat sources contribute to the rise in temperature in a room. Natural heat sources, such as the sun and geothermal, are the first to be considered. Biological heat sources, such as humans and animals, are the second source of heat. An electric mechanical heat source, such as machinery, lights, and other equipment, is the last heat source. The metabolic rate, ventilation rate of the garments worn, room temperature, room air humidity, and the speed of airflow on the skin surface are all factors that affect a person's thermal comfort [1].

Traditional structures are known as a source of information for sustainable, energy-efficient, and climate responsive design, despite modern buildings consuming much energy. One of the most noticeable differences between modern and traditional buildings in Indonesia is providing thermal comfort to occupants. The diversity of Indonesian cultures and customs are renowned. Its traditional dwellings reflect this diversity as well. The majority of traditional Indonesian houses conform to rules based on local customs or culture [2]. However, other houses are guided entirely by demands and technical considerations. Traditional houses, on the other hand, are noted for their excellent thermal performance. It is the reason of responding to the environment, materials and techniques available in the area, and the local way of life [3]. The houses are notable for using passive design principles to enhance thermal comfort. As previously said, traditional buildings are influenced by the local climate, and traditional Indonesian houses must thus be influenced by the country's hot and humid climate.

Indonesia is positioned between -11° and 6° latitude. Thus, it has a tropical climate. Due to Indonesia is an archipelago lying between the Pacific Ocean and the Indian Ocean, its climate is hot and humid. High average temperatures, little day-night and seasonal differences, high humidity, and copious rainfall are all characteristics of a hot and humid climate, as are high and relatively diffuse solar radiation [4]. Overheating may not be the most serious issue in this climate, but it is exacerbated by high humidity, limiting evaporation potential [5].

Traditional buildings dependability and existence have always been a source of architectural learning over the years. Modern architectural approaches can be filtered through local knowledge and wisdom.

The utilization of local materials and harmonization with the surroundings results in an adaptive design consistent with previous user behaviour.

2. Methods

Scientific publication in literature review is commonly conducted to generate a holistic understanding of a variable from various authors, research location, and authors' point of view [6][7]. Scientific literature on thermal comfort in traditional Indonesian houses were gathered in order to investigate how people treated internal and external circumstances in their houses to accomplish thermal comfort in the past. A total of twelve articles were chosen for synthesis, including one book, four journals, and seven proceedings. This research paper examines case studies of Indonesian traditional dwellings from various parts of the country. Table 1 shows a summary of the 12 publications.

3. Result And Discussion

Table 1. Outline of Literature Review

Author	**Type of publication**	**Location**	**Findings in thermal comfort**	**Keyword**
Izziah et al. 2021	Proceeding	Aceh	Cool air blown from beneath of then enter the house through timber floor [8]	Stilt house
Samra and Imbardi. 2020	Proceeding	Riau	Sufficient ventilation to maximize air circulation [9]	Windows size
Siahaan. 2020	Proceeding	Nias	Sloping and ventilated roof design maximizes air circulation; timber material responds the local climate; stilt house to decrease humidity from soil[10]	Sloping and Ventilated roof; material; Stilt house
Idham. 2018	Journal	Central Java and Yogyakarta	Wall height is lower than ceiling to allows hot air circulate upwards; house orientation towards sea to allocates natural cooling system [11]	Wall and ceiling arrangement; house orientation
Wiryomartono. 2014	Book	West Java	Naga community built their houses 35-40cm high from ground and remain space under the house empty for ventilation.[12]	Stilt house
Naing and Hadi 2020	Journal	South Sulawesi	Selected timber materials capable to maintain air humidity[13]	Material

Asriningpuri. 2020	Proceeding	Greater Jakarta	The existence of veranda as the respond to the local climate.[14]	Veranda
Yudantini. 2021	Proceeding	Bali	Proper percentage between building mass and open space allows smooth air circulation to buildings [15]	Open space
Kane,Mishra, and Dutta. 2016		Lampung Java Toraja	cross ventilation that occurs in the house is caused by the air movement trough the windows in the building[16]	window
Anwar. 2019	Proceeding	Southern Sumatera	change their behavior and activity to fulfil their comfort[17]	Behaviour and activity
Latif et al. 2019	Journal	Bugis	a roof that has a steeper slope or a larger attic volume reduces heat; Material variables exert a considerable influence on heat induction from the external environment. Houses that do not have ceilings, utilizing non-insulating materials on the roof, walls and ceilings are the source of excessive internal temperatures.[18]	Slooping and ventilated roof;Material; ceiling;
Lahji et al. 2011	Journal	Flores	using local materials such as fibers for roof, woods and bamboos for walls and floors, woods[19]	material

The thermal comfort of the static model and the thermal comfort of the adaptive model can be mentioned in the formation of thermal comfort in traditional buildings in Indonesia, according to the results of the literature review. Static thermal comfort is defined as thermal comfort that is established based on the idea that the thermal conditions in a room remain constant regardless of the temperature as well as differences in people's ability and behavior to adapt to the thermal environment. Several static models of thermal comfort are developed based on the above review and applied to traditional buildings, including: stilt houses; window size to maximize air circulation; ventilated roof design to maximize air circulation; wall and ceiling arrangements; house orientation; material; existence of veranda; open spaces; ceiling. If the static model fails to achieve thermal comfort, an adaptive model can be used, which is based on the idea that the temperature outside the building affects the temperature inside the building, and humans have the ability to interact with and adapt to different temperatures. The adaptive thermal comfort model is based on one's expectations of environmental thermal conditions based on historical memories, behavior patterns, and environmental thermal conditions. According to the literature assessment, one of the adaptive models in traditional structures is for people to adjust their behavior and activity to meet their comfort needs.

3.1 Stilt house

Stilt houses can be found in a variety of traditional Indonesian structures around the country. Several factors influenced people's decision to create stilt houses as their residential structures in the past. Izziah et al. noted in their article on the connection between traditional Acehnese houses and the current state of the modern Acehnese community that the stage's architecture tries to shield the stage's inhabitants from wild creatures. The development of such houses addresses the needs of the climate, particularly in terms of climate. Raising the house's floor to 2.5 meters allows cold damp air from the basement to be drawn into the house's rooms via wooden floors spaced at regular intervals. In his book about traditional settlements in Indonesia, Wiryomartono explains that Naga community in West Java built their houses 35-40cm high from ground and remain space under the house empty for ventilation. In his paper, Siahaan mentions another criterion for the installation of dwellings on stilts in Nias. The peaceful form of the house, which is located in hilly and forest locations, can protect the people from being attacked by wild animals. In terms of thermal comfort, these conditions are to avoid flooding and humidity, which can damage building materials [20].

3.2 Window

According to the SNI (Indonesia National Standards) of the General Department's regulations, a room in the Residential houses must have ventilation of at least 5% of the floor area of the room and windows of at least 10% of the floor area of the room [21]. The building'ssignificantly impactsimpact on the amount of work required to use wind for room conditioning. The size of the opening can be modified according to the wind flow requirements. The entrance and outlet area comparison affects the speed of the wind entering the room. The air velocity in the room will be lower than outside when the intake is greater than the outlet. The air velocity inside the room will be higher than outside when the inlet is smaller than the outlet. The effort to employ the wind in the air room conditioning is heavily influenced by the direction of the opening. The direction of motion and pattern of air in the air space will be determined by the guide at the intake, and the varying shapes of the guides will result in distinct airflow patterns. The leaf windows and louvers are the part of thutilised to guideuiding in the window opening [22]. According to Samra and Imbardi's article, Riau traditional home architecture is a sort of vernacular building that can be altered or created over time in response to changing needs and tropical circumstances on Sumatra's east coast [9]. The structure is constructed specifically for the tropics, so fresh air circulation is controlled through vents built into the walls. The concept is best suited for hot and humid tropical climates. To maximize the delivery of fresh air and reduce concentrations of cooking pollutants, penetrations are also discovered in kitchen walls and floors. Air circulation is a type of shaft ventilation in which the apertures are on opposing sides of the room . Similar case happened in Lampung traditional houses, The air movement in Lampung's traditional houses allows for cross ventilation. Air movement is primarily at or below window level, with the average amount of wind inside the room being lower than outside, and the average amount of wind inside the room being lower than outside. If the wind speed outside is slightly higher, turbulence has the ability to cause discomfort to occupants due to its pushing influence on incoming airflow [16].

3.3 Material

The heat of the sun enters the structure by conduction and solar radiation. The amount of sunlight that passes through the envelope. The type of material employed determines how the building envelope reacts to environmental conditions as the building's exterior layer. The building material acts as a barrier between the outside temperature and solar radiation and the internal temperature. The materials used in construction are influenced by the climate. The qualities and thickness of the material, as well as the color of the material outer surface, are all aspects to consider [23]. A material's thermal conductivity is a measurement of its ability to transfer heat. Heat transfer occurs at a low pace in materials with poor thermal conductivity; however, heat transfer occurs at a high rate in materials with high thermal conductivity [24].

The availability of resources in the surrounding environment influences material selection in traditional buildings. Due to technological and transportation limitations, ancestral local wisdom is used in a traditional Indonesian dwelling. As a response to the tropical climate, the Nias traditional house researched by Siahaan featured a roof with a sloping roof. Furthermore, wood, as the most common building material, can respond to changes in temperature and humidity. To shield the building from the blazing sun, woven leaves of thatch are used as a roof covering. Humidity is anticipated by positioning the column on a stone foundation and not directly touching the earth to avoid decay/weathering [20].

As detailed in the essay by Naidah Naing and Karim Hadi, similar considerations also exist in Bugis traditional dwellings. The materials utilized, such as ironwood, merbau, and spinach wood, are flexible, resilient, natural electrical insulators, capable of maintaining humidity at seasonal temperatures, and non-flammable [25].

The wave size on the zinc roofing material was sufficient to have a considerable effect on the intensity of heat entering the building, according to research conducted by Latif et al on traditional Bugis dwellings. The average internal temperature of dwellings with little corrugated tin roofs is higher than those with large corrugated zinc roofs. When it comes to wall materials, the highest temperature is achieved when zinc, wooden boards, and plywood are used, and the lowest temperature is achieved when gamacca is used.

The Gurusina indigenous people's local knowledge is supplemented by local culture in the use of local wisdom materials to feel comfortable and safe in a traditional dwelling that reflects three characteristics of thermal comfort: temperature, humidity, and wind flow. Traditional Flores houses are built with environmentally friendly sheathing materials that may be recycled in a short period of time (bamboo, palm fiber, wood). The state of the house accomplished the optimal of thermal comfort in the PMV analysis conducted by Lahji et al on the typical Flores house employing these materials. The thermal comfort level of inhabitants in a comfortable place thermal space is predicted using PMV analysis, which is affected by outdoor and indoor temperatures, occupant activities, and outerwear. Measurements of temperature, humidity, and wind speed, as well as interviews with occupants on the perceived thermal comfort, provide simulation data on field measurements.

3.4 Orientation

In order to profit naturally from heating and cooling systems, orientation must be in harmony with other aspects (Sungkoyo, 1995). According to Soetiadji (1986), the orientation of a shape is its location in relation to the base plane, cardinal directions, or the point of view of the observer. According to Soetiadji, the type of orientation is the result of the influence of orientation on anything, resulting in the building. Because the equatorial region receives a lot of radiation, it is the hottest place on the planet. According to Hamdani, Bekkouche, Benouaz, and Cherier (2012), in the case of housing, the building's orientation to the sun has a considerable impact on the temperature of the air in the room.

The majority of the vernacular dwellings in Java areas still adhere to the traditional housing layout and orientation. The Queen of the South Seas Nyai Roro Kidul and Dewi Sri are revered as the goddesses of land and fertility by the Javanese. As a result, the dwelling always faces south, and all functions other than offerings are prohibited in the central hall. Air circulation is also greatly aided by proper home orientation. Acclimatization is performed through the direction of the building in the smaller internal space of a beach home. The orientation of a house in the southern region of Java is beneficial not only for acclimating coastal dwellings, but also for inland dwellings that tend to take into account the South Sea breeze. The orientation of northern dwellings is related to the roadway rather than the breeze. North Java's coastal breezes are not as strong as those in the south, hence they have less of an impact on indoor air quality. Meanwhile, orientation is not a high priority in this area. Greater rooms, larger openings, and more porous envelopes assure air movement.

In North Nias, according to the Omo Hada settlement pattern, all houses face north-south, with the length of the house facing the road. This position provides natural daylight and ventilation, which is ideal for any home.

3.5 Sloping, ventilated Roof, and Ceiling

In Nias traditional house, the interior of the structure, protected from moisture, with the roof window (Lawa-Lawa) and lattices on the building's walls, which provide lighting and natural airing as well as allowing sunlight into the building. The building's high roof space helps to ensure that air circulation is optimized.

Bugis traditional house has similar condition, because the heat buildup process occurs faster on a triangular roof with a steeper slope or a bigger attic volume, it will be hotter than a roof with a steeper slope or a larger attic capacity. During the hot afternoon, houses without ceilings have a high average interior temperature. According to Ong (2011), solar radiation absorbed by the roof and immediately discharged to the occupants causes the high temperature in the interior of the home that is not shielded by the ceiling. As a result, ceilings constructed of wood are suitable for homes in humid tropical regions. In this situation, the ceiling height observed in research ranges from 200 to 265 cm. The room temperature drops as the ceiling rises. This finding is consistent with the findings of several prior investigations, which found that the air is stratified from the bottom to the top due to the high temperature. If the room is low, hot air will gather towards the top of the room, bringing the hot air closer to the effective human space.

3.6 Veranda and Outdoor spaces

The house's one-of-a-kindness is Because Betawian descendants are faithful to their customs or traditions, notably in taking care of ancestor ashes, the home has "meja abu" on the front area following veranda ("serambi"). Based on Asriningpuri's research, veranda use to restrain the sun glair or radiation of the sunlight that enterto the main house in frontage, to preserve the indoor temperature from the back sideuse the service area. Meanwhile in Balinese traditional house, outdoor spaces with traditional landscapes have the goal of being environmentally friendly while maintaining comfort for its residents, regulating the flow of air into the room, and adjusting lighting according to its function, as well as acoustic function that can be found in the outdoor of the housing. The building's composition pattern generates a plaza in the center called natah, which serves as a point of direction, circulation, an emergency point in the event of an earthquake, air circulation, and natural illumination for the structures.

3.7 Behaviour and activity

Traditional structures feature a passive design that uses less energy. Traditional structures are built to collect a lot of solar energy and use it sparingly. As a result, the zero-energy building design approach has been applied to conventional structures. The climate today is not the same as it was when the limas home was constructed. As a result, the user's behavior and activity may vary to accommodate their comfort. Because limas was built before electricity, the rooms relied on natural light from the windows. When electricity is available, artificial lights are used in each room during the day and at night. Only when natural lighting is insufficient are the lights used for daily activities. The windows were opened for natural lighting during the day for visual comfort. Artificial lighting is installed in all rooms and is only turned on at night. The natural lighting is adequate for the activities of the residents. The limas have electric fans in the bedroom and living area for further comfort. The afternoon and mid-afternoon were the most popular times to use a fan.

4. Conclusion

Indonesian traditional houses were designed in response to the region's climatic conditions. Certain arrangements of the house generate a thermal comfort system in a pearl of local wisdom. The genius loci of local wisdom values are less applied to current housings in Indonesia. The increase of timber materials and demand for modern-look houses fade these values away. However, another value lay in the traditional Indonesian houses, such as the arrangements of openings and house layout are still applicable to current architectural needs. The generous amount of windows applied in traditional Indonesian houses applies to current housing needs, which is in line with the green architecture issue to maximize natural ventilation and reduce the use of air conditioners. The verandah in the local wisdom of traditional Indonesian houses is also applicable to the current architectural realm due to tons of its function for thermal and acoustic comfort. Finally, this study reveals the local wisdom values of traditional Indonesian houses and contributes to building design knowledge with responses to the environment.

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