An evaluation of indoor thermal environment in fisherman housing in West Sumatera

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Abstract Pesisir Selatan is one of the districts in West Sumatra with a humid tropical climate with temperatures reaching 32°C during the day. The majority of coastal communities work as fishermen and build houses on the beach, such as in fishermen's housing in South Painan. In this area there are two models of fisherman housing, namely government-assisted fisherman housing and fisherman's original housing. Housing on the beachfront will be faced with quite extreme climatic conditions such as air velocity, air temperature, and air humidity which are relatively high on average. Therefore, it is necessary to evaluate the level of thermal comfort in the space in both models of fisherman housing to determine the performance of each fisherman's housing in dealing with the climate. This study uses a quantitative approach by measuring the parameters of thermal comfort, namely air temperature, humidity and air velocity using a thermohygrometer and anemometer. The data collection method uses descriptive quantitative. Comfort level is evaluated based on the Indonesian national standard (SNI 03-6572-2001) and adaptive thermal comfort. Based on the results of the study, the level of thermal comfort in both models of fisherman housing is classified as uncomfortable according to SNI 03-6572-2001 and adaptive thermal comfort.

1. Introduction

Housing on the beach will be faced with quite extreme climatic conditions. Wind speed, temperature and average humidity are relatively high, especially during the day so that it will cause discomfort in activities. Humans who are in the house with a bad thermal environment can have a negative effect on the comfort and health of residents [1]. South Painan is located on the Pesisir Selatan which is one of the regencies in West Sumatra Province. This area is located at 0.000 59' - 20 28.6' South Latitude and 1010 01" - 1010 30" East Longitude which has a humid tropical climate with temperatures reaching 32°C during the day. The position of the area to the sun which is determined by latitude and longitude makes climate differences in each place [2]. The latitude position in the tropics, has its own challenges to provide thermal comfort in indoor [3]-[4]-[5]. The majority of the population in South Painan work as fishermen and live on the beach. There are two models of fisherman housing in the same location, namely government-assisted fisherman housing and fisherman's original housing. The most visible problem in these two models of fisherman housing is that the residents prefer to relax outside the house such as on the terrace during the day.
Thermal comfort is a feeling where a person feels comfortable with the temperature state of his environment, which can be described as a condition where a person does not feel hot or cold in a certain environment [6]. Thermal comfort standards already exist in SNI 03-6572-2001 [7]. There are three levels of comfortable temperature for Indonesians in °C ET units, the °C ET value is obtained from a combination of air temperature, relative humidity and air velocity. Thermal comfort limits according to SNI 03-6572-2001 can be seen in Table 1 below:

| Thermal Comfort Level          | Effective Temperature (ET) | Relative Humidity / RH (%) |
|--------------------------------|-----------------------------|----------------------------|
| Cool Comfortable               | 20.5 °C ET - 22.8 °C ET     | 50 %                       |
| Optimal Comfort                | 22.8 °C ET - 25.8 °C ET     | 70 %                       |
| Warm Comfortable               | 25.8 °C ET - 27.1 °C ET     | 60 %                       |

In a study conducted by Tri Harso Karyono [8], the human body has an adaptive ability to adapt to the thermal environment. The comfortable temperature in each area also differs according to the average outdoor temperature. Karyono's study on thermal comfort in several regions in Indonesia resulted in the following equation:

\[
PCT = 0.749 Td + 5.953 \quad \text{……... (1)}
\]

PCT is the predicted comfort temperature and Td is the average daily outdoor temperature.

There are several thermal comfort standards. However, in this study only the above two standards are applied to evaluate the indoor thermal environment in fisherman housing

2. Research method

2.1. Types of research
This type of research is a quantitative descriptive research. Research on thermal comfort in fishermen's housing is carried out by measuring air temperature, relative humidity and air velocity.

2.2. Location and time of research
The research was conducted on fisherman's housing in South Painan, Pesisir Selatan Regency, West Sumatra Province, which consisted of government-assisted fisherman's housing and fisherman's original housing, each housing sample taken 2 houses for research. In the government-assisted fisherman housing, 2 houses representing the north and south orientations were selected with a minimum of 4 occupants. In the fisherman's original housing, 2 houses were also selected consisting of semi-permanent and non-permanent houses with a minimum of 4 occupants. Each house was measured for 2 days in the living room. The implementation of the research starts from February 16, 2021 until February 23, 2021, starting from 07.00-17.00 WIB.

Figure 1. Map of South Painan.
2.3. Research instruments

2.3.1. Air temperature
The instrument for utilized to measure the air temperature is digital thermo-hygrometer with the Chino brand, as shown in Figure 2. This tool is also capable of reading relative humidity, in this case the air temperature indicator is used.

![Thermo-Hygrometer](image1)

**Figure 2.** Thermo-Hygrometer.

2.3.2. Relative humidity
The instrument for measuring relative humidity is a digital thermo-hygrometer which can also be used to measure air temperature, as shown in Figure 2. In this case, the relative humidity indicator is used.

2.3.3. Air velocity
The instrument for measuring air velocity in the room is a digital anemometer with the brand Prova AVM-03, as shown in Figure 3.

![Anemometer](image2)

**Figure 3.** Anemometer.

2.4. Data analysis techniques
Data analysis carried out in this study used quantitative analysis. The measurement data were analyzed using psychometric charts [9] to obtain the value of the wet bulb temperature (WBT). The WBT value is obtained from the dry bulb temperature (DBT) and air humidity (Rh) values which are connected in a psychometric graph. After the WBT value is obtained, the monogram graph [10] is used to obtain the effective temperature value by connecting the DBT, WBT and air velocity values. Furthermore, the effective temperature value that has been obtained is compared with the value of SNI 03-6572-2001 to see the level of thermal comfort.

Prediction of comfortable temperature from adaptive thermal comfort is obtained from the Tri Harso Karyono equation [8]. The average outdoor air temperature data is obtained from the Meteorology, Climatology, and Geophysics Agency. Then the data is entered into the formula to get a comfortable temperature value. After that, the temperature measurement results are entered into a graph to see the level of thermal comfort in each house based on the comfortable temperature value.

3. Results and discussion

3.1. Data description
3.1.1. Situation analysis
This measurement was carried out at fishermen's housing in South Painan, Pesisir Selatan Regency, West Sumatra Province. There are two models of fisherman housing at that location, the first is a government-assisted fisherman's house (GAFH) of type 36 with 50 units, already permanent, has a living room, two bedrooms, and one bathroom. The housing is oriented north-south. The second
housing is the fisherman's original house (FOH) which is located on the beach with different shapes. Some are permanent, semi-permanent and some are not. The housing here is generally oriented towards the sea, namely the West.

3.1.2. Measurement location

Figure 4. Measurement locations in fishermen's housing.

Information:

- Government Assistance Fisherman's House (GAFH)
- Fisherman's Original House (FOH)

Measurements were made on four selected houses, two houses in government-assisted fisherman housing and two houses in fishermen's original housing.

3.1.3. Measuring points

Measurements were made in the living room on both models of fisherman housing. Measurements were made to measure air temperature, relative humidity, and air velocity in the room.

Figure 5. (a) Government Assisted Fisherman's House (GAFH) 1 (b) Government Assisted Fisherman's House (GAFH) 2.

Figure 6. (a) Fisherman's Original House (FOH) 1 (b) Fisherman's Original House (FOH) 2.
3.2. Measurement results
3.2.1. Air temperature and relative humidity

![Figure 7](image_url)

**Figure 7.** Measurement results of air temperature and relative humidity in both models of fisherman housing.

Based on Figure 7, it can be seen the value of air temperature and relative humidity in each fisherman's house. In GAFH 1 and GAFH 2, the average outdoor air temperature is higher than the indoor temperature, this is inversely proportional to the humidity of the air. The relative humidity in the indoor air is on average higher than the humidity in the outdoor room, this condition can be affected by the lack of air circulation in the room.

In FOH 1 and FOH 2, the average indoor air temperature is higher than the outdoor air temperature. This is inversely proportional to the relative humidity. The average relative humidity in the outdoor is higher than the indoor relative humidity, this condition is influenced by the location of FOH 1 and FOH 2 which are on the beach and facing the sea.

3.2.2. Air velocity

![Figure 8](image_url)

**Figure 8.** The results of air velocity measurements in both models of fishermen's housing.
Based on Figure 8, it can be seen that, at GAFH 1 and GAFH 2 the average air velocity in the outside room is higher (pleasant) than the air velocity in the inside (unnoticed). The air velocity is not felt in the room because the facade and openings are not oriented towards the direction of the wind.

In FOH 1, the average outdoor air velocity is higher (draughty) than the indoor air velocity (awareness of air movement). The outdoor air velocity is quite different compared to the indoor air velocity, but the air can still be felt inside the room. The air velocity felt was quite strong compared to the previous houses. This is also influenced by the orientation of the house which directly faces the sea, so it gets a fairly strong sea breeze.

In FOH 2, the average air velocity in the outdoor room is higher (pleasant) than the air velocity in the indoor room (unnoticed). The air velocity on FOH 2 looks much different from FOH 1, although it is also oriented to the west, the air velocity on FOH 2 is not too strong because it is blocked by the building in front of it.

3.3. Discussion
3.3.1. Indonesian National Standard (SNI 03-6572-2001)

Based on Figure 9, it can be seen the level of thermal comfort in each fisherman's house in the effective temperature based on SNI 03-6572-2001. GAFH 1 was included in the uncomfortable sensation on both the first and second day. GAFH 2 on the first day provides an optimal comfort sensation at 07.00 and warm comfortable at 08.00. For 09.00-17.00 it is included in the uncomfortable category according to SNI 03-6572-2001. On the second day there is a warm comfortable sensation at 07.00 but for 08.00-17.00 it is included in the uncomfortable category according to SNI 03-6572-2001. The average effective temperature value at GAFH 2 is still uncomfortable.

FOH 1 on the first and second days gave a warm comfortable sensation at 07.00 but at 08.00-17.00 it was included in the uncomfortable category according to SNI 03-6572-2001. FOH 2 on the first day provides an optimal comfort sensation at 07.00 and warm comfortable sensation at 17.00. However, at 08.00-16.00, it is included in the uncomfortable category according to SNI 03-6572-2001. On the second day there is an optimal comfort sensation at 07.00, but for 08.00-17.00 it is included in the uncomfortable category according to SNI 03-6572-2001. The average effective temperature value on FOH 1 and FOH 2 is still uncomfortable.
3.3.2. Adaptive thermal comfort

Adaptive thermal comfort adapted to the average outdoor temperature. The average outdoor temperature data is sourced from Meteorology, Climatology, and Geophysics Agency. The study of adaptive thermal comfort refers to the study conducted by Tri Harso Karyono [8]. Karyono conducted a study of several studies of thermal comfort in several regions in Indonesia and produced an equation:

\[ PCT = 0.749T_d + 5.953 \]  

The average outdoor temperature value is entered into the above equation and then the comfortable temperature value is obtained as shown in table 2 below:

| Table 2. Painan comfortable temperature range. |
|-----------------------------------------------|
| Max  | Min  | Avg  |
| °C   | °C   | °C   |
| T_d  | 33   | 24.8 | 28   |
| T_c  | 30.6 | 24.5 | 26.9 |

PCT = Predicted comfort temperature  
T_d = Average daily outdoor temperature

Based on Figure 10, it can be seen the level of thermal comfort in each fisherman's house based on adaptive thermal comfort. The air temperature of GAFH 1 on the first and second days at 07.00 is below the maximum comfort line and is included in the comfortable temperature. For 08.00-17.00, it is above the maximum comfort line so that it does not include comfortable temperatures. The average air temperature at GAFH 1 is included in the uncomfortable category based on adaptive thermal comfort.

The air temperature of GAFH 2 on the first day at 07.00, 08.00, 09.00, and 17.00 was below the maximum comfort line and included in the comfortable temperature. Meanwhile, 10.00-16.00 is above the maximum comfort line so that it does not include comfortable temperatures. On the second day at 07.00, 08.00 and 17.00 are below the maximum comfortable line and can be said to be included in the comfortable temperature. Meanwhile, 09.00-16.00 is above the maximum comfort line so that it does
not include comfortable temperatures. The average air temperature at GAFH 2 is also included in the uncomfortable category based on adaptive thermal comfort.

The air temperature of FOH 1 on the first and second days at 07.00 is below the maximum comfort line and is included in the comfortable temperature. Meanwhile, 09.00-17.00 is above the maximum comfort line so that it does not include comfortable temperatures. The average air temperature on FOH 1 is also included in the uncomfortable category based on adaptive thermal comfort.

The air temperature of FOH 2 on the first day at 07.00, 08.00, and 17.00 was below the maximum comfort line and included in the comfortable temperature. Meanwhile, 09.00-16.00 is above the maximum comfort line so that it does not include comfortable temperatures. On the second day at 07.00, 08.00, 09.00, 16.00, and 17.00 are below the maximum comfort line and can be said to be included in the comfortable temperature. Meanwhile, 10.00-15.00 is above the maximum comfort line so that it does not include comfortable temperatures. The average air temperature on the FOH 2 is also included in the uncomfortable category based on adaptive thermal comfort.

4. Conclusion
Based on the analysis and research results, it can be concluded that the level of thermal comfort in both models of fisherman housing is classified as uncomfortable based on SNI 03-6572-2001 and adaptive thermal comfort. Further research is needed to determine the thermal comfort of the user's perception in the house using a questionnaire. The use of thermal and airflow simulation is also recommended to obtain the pattern of airflow and heat in the room.

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