SSRG International Journal of Civil Engineering
ISSN: 2348-8352/ https://doi.org/10.14445/23488352/IJCE-V12I9P107

Volume 12 Issue 9, 74-90, September 2025
© 2025 Seventh Sense Research Group®

Original Article

From Climate to Clothing: Thermal Exposure and Dress Choices among Fishermen in Humid Coastal Environments

Idawarni Asmal

Department of Architecture, University of Hasanuddin, South Sulawesi, Indonesia.
Infrastructure Planning Engineering, postgraduate, Hasanuddin South Sulawesi, Indonesia.

[1]Corresponding Author : idawarniasmal@yahoo.com

Received: 08 July 2025 Revised: 09 August 2025 Accepted: 07 September 2025 Published: 29 September 2025

Abstract *- This study explores the behavioral adaptation of coastal fishermen to thermal comfort in humid tropical climates, focusing on the use of outdoor spaces and clothing choices to mitigate extreme temperatures. The novelty of this research lies in its integration of spatial preferences, clothing, and building design to understand how these factors collectively influence comfort and productivity in coastal communities. Field surveys were conducted, including temperature measurements across different spaces (indoor, under-house areas, yards, and green open spaces) and interviews with fishermen regarding their habits and preferences. The findings reveal that fishermen prefer shaded outdoor spaces, such as under-house areas (kolong) and yards, which offer lower temperatures than indoor environments. Minimal clothing, such as sarongs or shorts, is commonly worn to alleviate heat. The study highlights the importance of thermal-sensitive building designs and shading devices in improving comfort. The paper also recommends enhancing outdoor space quality, improving building designs with better insulation and ventilation, and educating fishermen about climate-appropriate clothing to enhance their comfort and productivity. This research contributes new insights into how thermal comfort can be optimized through a combination of spatial adaptation and behavioral strategies, providing practical recommendations for designing sustainable environments for coastal fishermen in tropical climates.*

Keywords *- Thermal comfort, Behavioral adaptation, Outdoor spaces, Clothing, Coastal fishermen, Tropical climate, productivity.*

1. Introduction

1.1. Back Ground

Coastal fishing communities play a vital role in supporting local economies and food security, particularly in tropical regions where fisheries constitute a primary livelihood. However, their dependence on marine resources makes them highly vulnerable to climate change impacts, such as rising sea surface temperatures and shifting weather patterns, which threaten marine ecosystems and the sustainability of their livelihoods.

A major challenge faced by these communities is thermal discomfort due to increasing ambient temperatures and prolonged sun exposure-conditions exacerbated by climate change. Fishermen often spend extended hours outdoors catching fish, processing their haul, and maintaining equipment, leaving them exposed to extreme heat and humidity. This environmental stress significantly endangers their health, well-being, and work productivity, heightening the risk of fatigue, dehydration, and heat-related illnesses.

Furthermore, their settlements-often informally constructed-tend to lack thermally efficient building design. Poor ventilation, insufficient shading, and the use of heat-retaining materials aggravate indoor heat stress. Combined with the need for strenuous physical labor under direct sunlight, these conditions further increase their vulnerability to thermal stress.

1.2. Current Issue

In the absence of adequate infrastructure or technological interventions, coastal fishermen rely on behavioral and spatial adaptations to cope with extreme thermal conditions. These include adjusting work routines, seeking shade during peak heat hours, modifying clothing, and enhancing airflow in living and resting spaces.

Recent studies underscore the critical importance of achieving thermal comfort in tropical climates, where temperature and humidity often exceed optimal human thresholds. Research by Dec et al. [1] and Alsmo & Alsmo [2] highlight the role of air circulation and humidity control in maintaining thermal comfort. National and international standards, such as SNI 03-6572-2001 and ASHRAE [3], provide benchmarks for acceptable indoor and semi-outdoor thermal conditions, including temperature, humidity, and air velocity. Clothing also plays a key role in thermoregulation. Studies by Ogulata [4] and Kwon & Choi [5] emphasize the effects of fabric type, ventilation, and fit on heat dissipation. Spatial configurations and microclimate design further contribute to reducing outdoor heat stress, as demonstrated by Kubota et al. [6] and Singh et al. [7], who explored the relationship between thermal environments and user adaptation. Therefore, integrating user behavior and spatial planning is essential for designing climate-resilient solutions for vulnerable communities.

1.3. Research Gap and Problem Introduction

Despite extensive research on thermal comfort in urban, office, and formal residential environments, there has been limited scholarly attention to occupational groups such as coastal fishermen, whose livelihoods and daily activities expose them to unique thermal conditions. These communities are characterized by informal spatial arrangements, open or semi-open living and working environments, and elevated wooden housing structures, all of which demand context-specific approaches to understanding thermal adaptation. The majority of existing literature remains focused on indoor thermal comfort or regulated built environments, particularly in temperate and arid climates [8, 9], thereby overlooking populations whose exposure patterns are shaped by outdoor and mobile settings that heighten vulnerability to environmental heat stress.

Research on vernacular architecture and bioclimatic design has emphasized climate-responsive housing and passive cooling strategies [10-12]. However, these studies often marginalize communities' everyday spatial behaviors and adaptive practices in humid tropical coastal regions-particularly fishing settlements where informal housing typologies prevail. This omission is significant given that such communities, unlike formal urban residents, have limited access to mechanical cooling technologies and rely heavily on spatial improvisation and culturally embedded adaptive strategies to cope with thermal stress [13].

Moreover, existing thermal comfort models largely prioritize physiological or material aspects of heat exposure, such as building materials, insulation, or clothing [9, 14]. While useful, these perspectives often neglect the integration of empirical environmental data (ambient temperature, humidity, wind flow), behavioral responses (daily routines, clothing adjustments, use of shaded spaces), and spatial strategies (use of under-house areas, orientation toward prevailing winds) that are vital in tropical fishing contexts. This gap in the literature underscores the absence of holistic frameworks that connect thermal comfort with socio-spatial practices and occupational realities in low-income coastal communities [15]. The urgency of addressing this research gap is amplified by climate change, which is projected to increase the frequency and intensity of extreme heat events in tropical regions [16, 17]. Fishing communities, already socially and economically vulnerable, face heightened risks to occupational health, productivity, and well-being. Yet, they remain underrepresented in both architectural and environmental comfort research. This study, therefore, responds to these gaps by examining how coastal fishermen in humid tropical environments adapt to thermal stress through a combination of spatial, architectural, and behavioral strategies, including clothing practices as a culturally embedded adaptive mechanism. By situating these responses within the broader socio-environmental and occupational context of informal fishing settlements, the research contributes to a more nuanced understanding of everyday climate adaptation. Ultimately, it seeks to propose design-based recommendations that enhance thermal resilience, safeguard occupational health, and improve spatial quality in vulnerable coastal communities.

1.4. Research Novelty

The novelty of this study lies in its focus on coastal fishing communities in humid tropical environments, a population that has been largely neglected in previous thermal comfort research. While earlier studies have examined thermal comfort in regulated indoor environments [8, 9] and explored passive strategies within vernacular housing and bioclimatic design [10-12], these works have rarely addressed the lived experiences of low-income groups working in semi-open, mobile, and climatically exposed settings. Furthermore, research on thermoregulation through clothing [4, 5] and spatial configurations [6, 7] has tended to isolate physiological or design variables, rather than examining how they intersect with behavioral routines, socio-cultural practices, and occupational realities. By integrating environmental parameters (temperature, humidity, airflow) with spatial strategies (use of shaded and under-house areas) and culturally embedded behavioral adaptations such as clothing practices, this study moves beyond the fragmented perspectives of existing literature. It establishes a holistic framework that positions thermal comfort as a physiological requirement and a socio-spatial and cultural adaptation strategy. In doing so, it contributes original insights into how vulnerable fishing communities can enhance thermal resilience in the face of intensifying climate change, thereby extending the discourse on environmental comfort and adaptive design into contexts that have hitherto remained underexplored.

1.5. Research Objection

This study aims to explore and analyze thermal comfort and spatial and behavioral adaptation strategies implemented by coastal fishing communities in tropical areas, especially in dealing with increasing exposure to extreme heat and high humidity due to climate change. Specifically, the objectives of this study include: 1. Identifying actual thermal conditions in the residential environment and fishermen's workspaces (temperature, humidity, air circulation), and comparing them with national (SNI 03-6572-2001) and international (ASHRAE, 2010) [3] thermal comfort standards. 2. Analyzing the forms of behavioral adaptation carried out by fishermen, such as changes in activity time, clothing use, and strategies to avoid heat, referring to the findings of Kwon & Choi [5], Ogulata (2007) [4], and Singh et al. [7]. 3. Evaluating the spatial and architectural characteristics of fishing settlements that affect thermal comfort, including natural ventilation, the presence of open spaces, and the use of building materials [6, 18], 4. Formulate recommendations for tropical climate-based designs that are responsive to the needs of fishermen to increase the resilience of their residential environment to heat stress in a sustainable manner.

1.6. Research Questions

To achieve these objectives, this study formulates several main questions: 1. What are the actual thermal comfort conditions experienced by coastal fishing communities in tropical areas? → Based on temperature, humidity, and air circulation parameters, and compared to SNI 03-6572-2001 and ASHRAE [3] standards. 2. What are the forms of behavioral adaptation and clothing use carried out by fishermen to reduce thermal discomfort? → Referring to the studies of Kwon & Choi [5], Ogulata [6], and Singh et al. [7]. 3. How do the spatial and physical characteristics of fishing settlements contribute to the level of thermal comfort and heat stress? → Referring to the findings of Kubota et al. [6] and Rijal et al. [18]. 4. What design strategies can be applied to improve thermal comfort ecologically and socially in tropical coastal fishing settlements? → Refer to sustainable and community-based design approaches.

2. Literature Review

2.1. Human Behavior, Microclimate, and Thermal Conditions

Foundational work demonstrates that people continuously tune their behavior to thermal stimuli. Early studies with schoolchildren documented responses through clothing, posture, and appearance [19]. Behavioral choices are shaped by external thermal conditions, weather expectations, and activity types [20], while microclimates strongly mediate outdoor use and social patterns [21].

At higher temperatures-especially during heat waves-heat stress elevates morbidity and suppresses productivity; individuals preferentially rest and seek shade. For example, when air temperature exceeded ~20 °C in temperate settings, people shifted to shaded areas and overall attendance in public spaces declined [22]; see also Kuo-Tsang Huang [23] for shaded-space preferences in hot weather. Standards and benchmarks formalize acceptable thermal ranges. Indonesia's SNI 03-6572-2001 remains a key national reference for ventilation and air-conditioning design in buildings, including guidance pertinent to indoor and semi-outdoor thermal parameters (dry-bulb temperature, humidity, air movement). At the international level, ASHRAE Standard 55 [24] codifies acceptable thermal environmental conditions; the most recent release is ASHRAE 55-2020 (with addenda through late 2023), reflecting evolving knowledge on comfort evaluation in mechanically conditioned and naturally ventilated spaces. Beyond standards, the ASHRAE Global Thermal Comfort Database II consolidates ~76k–82k field observations worldwide and underpins contemporary adaptive models relevant to varied climates, including the tropics. Recent critical reviews further synthesize outdoor and semi-outdoor thermal comfort advances, highlighting micro- to macro-scale determinants (radiation, wind, shading, materials) and calling for context-specific models in hot-humid regions.

Behavioral thermoregulation is not uniquely human: classic ecological work shows organisms (e.g., desert lizards) depend on sheltering behavior to survive peak heat—an analogue for human recourse to shade, airflow, and timing strategies under extreme conditions [25]. The adaptive opportunity concept captures this: greater occupant control over environment or requirements reduces thermal stress likelihood, as widely cited from Sally Shahzad et al [26] in the thermal comfort literature [8].

Application to fishermen's settlements. Recent Indonesia-based research develops models to determine thermal comfort in fishermen's residential areas under humid tropical climates, linking environmental measurements with residents' activities and space use [27]. Such work clarifies how temperature and humidity patterns shape outdoor routines and points toward designable levers (shade, ventilation paths, resting niches) for resilience.

2.2. Temperature and Clothing

Clothing is a primary, low-cost buffer for heat stress. Reducing clothing insulation (lighter, looser, more breathable fabrics) directly improves heat dissipation and subjective comfort, especially in hot, humid contexts [4, 5, 28]. Field studies indicate comfort with thin-insulation ensembles (≈0.4-1.01 clo) at warm outdoor temperatures, provided air movement and shading are adequate [6]. Clothing choice is dynamic: even if morning selections are weakly linked to indoor temperature, people adjust garments throughout the day as conditions change [29, 30].

Importantly, new evidence connects clothing choices to outdoor thermal comfort and activity intensity in real urban settings; a 2024 study in Porto demonstrates how tourists' apparel adapts to microclimatic conditions and physical activity levels-evidence transferable to other outdoor-exposed groups. Hélder Silva Lopes et al. [31], findings reinforce that apparel, fit, and ventilation (garment micro-air layers) are critical variables alongside microclimate control.

2.3. Strengthening the Resilience Lens: Fishermen's Behavior, Clothing, and Space Use

Across hot-humid settlements, adaptive behaviors in naturally ventilated environments-timing work, exploiting breezes, seeking shade, and tuning clothing-are central to comfort [28]. Yet studies that integrate all three layers (1) environmental metrics (air temperature, humidity, wind, and mean radiant temperature), (2) clothing/behavior dynamics, and (3) spatial strategies (use of kolong/under-house spaces, jetty edges, wind corridors, and shaded courtyards)—in the specific context of coastal fishing communities remain scarce. Recent systematic and critical reviews of outdoor thermal comfort explicitly call for such context-rich, population-specific models, especially in hot-humid regions where radiant heat, moisture, and low diurnal range complicate adaptation [32, 33] Building on this trajectory, the present research examines fishermen's joint behavior–clothing–space adaptations to articulate designable interventions (e.g., wind-aligned resting bays, modular shading, breathable materials, and culturally aligned clothing guidance) that align with national and international [24] benchmarks while remaining responsive to the informal, semi-open realities of coastal settlements.

3. Study Area

The research location occurred in several fishermen's settlements on the southern coast, North Takalar Regency, South Sulawesi, Indonesia. The settlement is located in the coastal area and is directly adjacent to the Makassar Strait, shown in Figure 1.

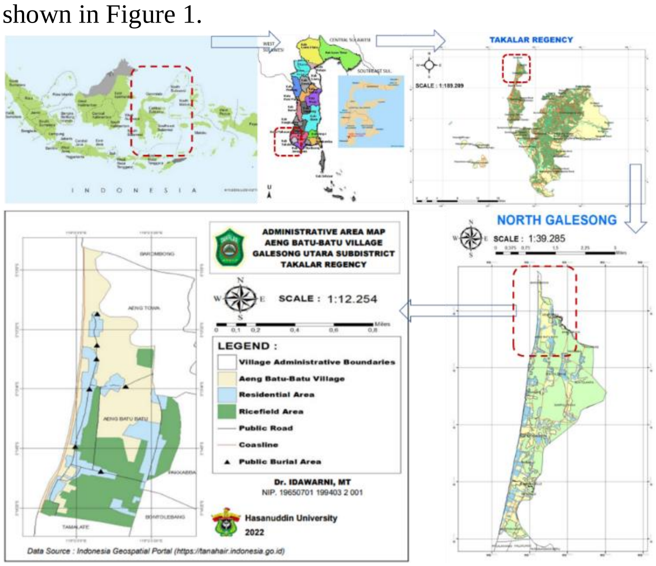


Fig. 1 Research location North Galesong-Takalar regency

The climatological conditions in Takalar Regency are as follows: the rainy season is usually cloudy, the dry season is windy and partly cloudy, and it is generally hot and scorching throughout the year. Based on the observations of rain stations in Takalar Regency, it shows that the minimum air temperature on average is 22.2 ˚C to 20.4^{O}C from February to August, the maximum reaches 30.5^{O}C to 33.9^{O}C in September-January, humidity ranges from 60% – 82 %, and an average wind speed of 2-3 knots/hour (Statistics of Takalar Regency area, 2016).

4. Methodology

4.1. Research Approach

This study employed a quantitative research approach to investigate the relationship between microclimatic conditions and fisher behavior in stilt house settlements in Galesong Utara, Takalar. The research focuses on the thermal comfort conditions in and around traditional stilt houses and how these affect the behavior and adaptive strategies of local fishers. To investigate the causal relationship between climatic stressors and fisher adaptation, particularly focusing on clothing behavior as a key indicator of thermal coping strategy.

4.1.1. Block Diagram

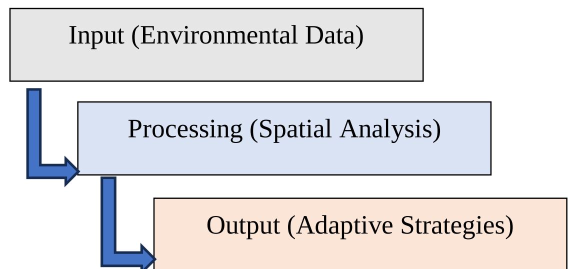


Fig. 2 Block diagram

4.1.2. Flow Diagram

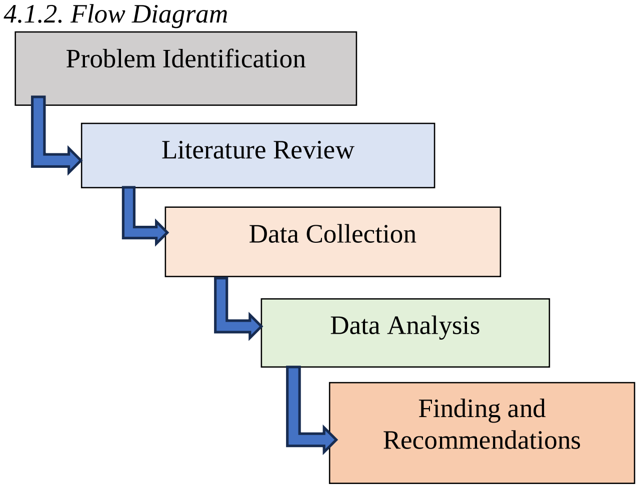


Fig. 3 Flow diagram

4.2. Types of Data

The research utilized two main types of data:

- Climate Data: Includes temperature, humidity, and wind speed, measured both indoors (inside the stilt houses) and outdoors (around the houses and public spaces).
- Behavioral Data: Observations and self-reported data regarding fisher preferences, activity locations, clothing choices, and adaptation strategies in response to local microclimates.

4.3. Sampling Method

4.3.1. Climate Data Sampling

A total of 48 stilt houses were randomly selected from the hamlets of Karama and Ujung Kassi, representing 39% of the total 124 stilt houses in the area. The two hamlets were chosen due to:

- Their proximity to the sea.
- Their representativeness of typical coastal settlement conditions in South Sulawesi.
- Their logistical accessibility from the city of Makassar.

Each house was equipped with measuring devices for 1 x 24 hours during a consecutive 48-day period.

4.3.2. Behavioral Data Sampling

Behavioral data were collected using accidental (incidental) sampling, a non-probability technique where data were obtained by interviewing whoever was present at the time of observation (Sugiyono, 2010).

This method was chosen due to the sporadic and uncountable nature of fisher activities in open spaces.

4.4. Sample Size Calculation

Sample size for behavioral observation was determined using the Linear Time Function (LTF) formula (Mustaniroh et al., 2011) [34]:

Follows in Equation 1:

$$N = (T = t0): t1 \quad (1)$$

Note: T = Time available for research, 14 days, Morning

Time: 10.00 - 1.00 WITA (3 hours), (3 hours x 60 minutes x 14 days) = 2520 minutes. T0 = Fixed time (3 hours daily timeframe), (3 hours x 60 minutes = 180 minutes).

t1 = Time to fill out the questionnaire (20 minutes)

N = Number of times selected samples. Calculation of the number of samples taken from visitors is as follows:

$$N = (T = t0): t1$$

N = (2520 minutes - 180 minutes): 20. →N = 117.

Hence, a total of 117 respondents were expected to be surveyed during the morning period (10:00–13:00 WITA), which aligns with fishers' return time from sea activities.

4.5. Data Collection Techniques

4.5.1. Climate Data Collection

- Sensor Tools: Indoor and outdoor temperature and humidity were measured using Ux100-003 Ux100Tmp/RH and MX2302/RH Sensor Data Loggers.
- Thermal Imaging: A handheld HT-02 infrared thermal camera was used for comparative validation.
- Observation Period: Data were collected during the dry season (April to July 2023), a period associated with increased temperatures and active fishing routines.

4.5.2. Behavioral Data Collection

- Interviews and Surveys: Fishers were asked about their clothing preferences, activity locations, comfort perceptions, and adaptation behaviors.
- Field Observations: Researchers noted fishers' movement and spatial patterns across the settlement.

Respondents were asked specific questions about the type of clothing worn during fishing activities (e.g., material, color, layering), their reasons for these choices, and perceived thermal comfort under such conditions.

4.6. Spatial Data and GIS Integration

To strengthen environmental contextualization, spatial analysis using GIS was integrated:

- Spatial Mapping: GPS coordinates were recorded for all 48 stilt houses and key outdoor activity spots.
- Base Maps: Settlement maps were digitized using satellite imagery and shapefiles from the Geospatial Information Agency (BIG).
- Interpolation: Inverse Distance Weighting (IDW) methods were used to create temperature and humidity distribution maps.
- Overlay Analysis: Behavior patterns and climate maps were overlaid to identify spatial discomfort or adaptive activity hotspots.

4.7. Data Analysis Techniques

- Descriptive Analysis: Climate variables were summarized using averages, ranges, and frequency distributions. Behavioral data were categorized based on location, time, and type of adaptation.
- Correlation Analysis:
  - Pearson's Correlation Coefficient was used for normally distributed data.
  - Spearman's Rank Correlation was used for non-normally distributed data.
  - The analysis examined relationships between:
    - ✓ Temperature and location of activities.
    - ✓ Temperature and clothing choices.
    - ✓ Humidity and duration of stay in specific areas.
- Spatial Analysis: GIS was used to:
- Identify zones of thermal discomfort.
- Compare behavioral adaptation patterns spatially.
- Generate heatmaps of thermal pressure in residential and communal zones.
- Clothing behavior clusters were mapped and overlaid with microclimate zones to detect spatial patterns of thermal adaptation.

Analysis included identifying dominant trends as well as outlier behaviors to explore variations in clothing adaptation strategies across age and occupation type.

Table 1. Methodology suitability with research objectives

Research Components	Research Objectives	Methods Used	Assessment
Microclimate (temperature & humidity)	Assessing thermal conditions inside and outside fishermen's stilt houses	Data Logger Sensor (Ux100, MX2302), HT-02 thermal camera	Very appropriate, the tools and time of data collection are relevant and specific to the dry season
Response and adaptation of fishermen's behavior	Identifying fishermen's adaptive behavior to heat	Interviews, direct observation, and incidental surveys with LTF estimates	Appropriate, observational approaches and direct surveys are effective in capturing the reality of adaptive behavior
Clothing preferences and use of space	Analyzing the relationship between temperature and adaptation strategies (clothing, activity location)	Interviews, observations, and visual documentation	Appropriate, allows for detecting casual responses to environmental variables
Spatial relevance (location of fishermen's activities)	Assessing the distribution of activity space and thermal comfort levels	Observation of activity locations, temperature/humidit y measurements per zone	Relevant for creating mapping and zone-based design interventions
Analysis of variable relationships	Testing the relationship between temperature, location, and adaptive behavior	Pearson/Spearman correlation	In accordance with the purpose of identifying causal relationships between environmental factors and behavior

5. Result and Discussion

5.1. Climate Data

Room temperature measuring the air temperature is done in a stage house, located directly adjacent to the beach. The internal Ux100-003 Ux100Tmp / RH device and infrared camera show the movement of temperature in space, which is depicted in Table 2.

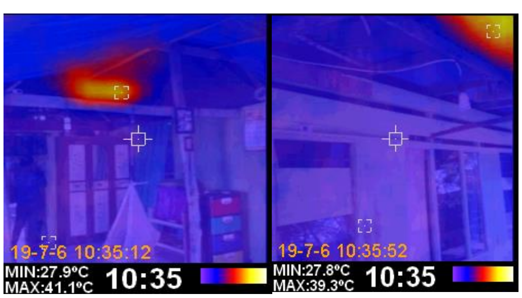
Table 2. Temperature indoor and outdoor (kolong)

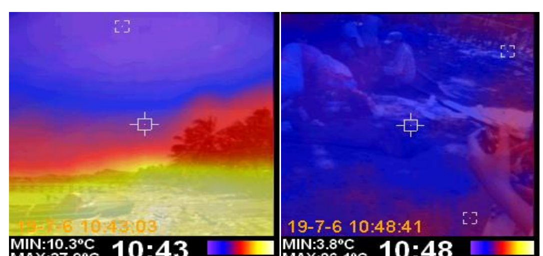
Time	Temperature Average For 48 House Units		Moisture Average For 48 House Units		Deviation of Indoor And Outdoor Temperature and Humidity	
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor
0:30	26.23	26.28	79.97	80.44	0.05	0.47
1:00	26.08	26.14	80.52	80.95	0.05	0.43
1:30	25.97	26.02	80.96	81.48	0.05	0.52
2:00	25.82	25.91	81.60	81.87	0.09	0.27
2:30	25.66	25.75	82.09	82.48	0.09	0.38
3:00	25.52	25.64	82.71	83.08	0.12	0.37
3:30	25.39	25.52	83.23	83.23	0.13	0.00
4:00	25.27	25.41	83.72	83.65	0.14	-0.07
4:30	25.15	25.31	84.03	84.01	0.16	-0.02
5:00	25.03	25.22	84.86	84.56	0.19	-0.30
5:30	24.92	25.08	85.01	85.04	0.16	0.03
6:00	24.86	25.02	85.54	85.36	0.16	-0.18
6:30	24.30	24.98	85.88	85.60	0.67	-0.28
7:00	25.53	25.37	84.83	84.99	-0.16	0.17
7:30	26.38	26.03	81.63	82.21	-0.35	0.59
8:00	27.75	26.60	76.53	79.78	-1.15	3.24
8:30	29.36	27.67	70.15	75.71	-1.69	5.56
9:00	30.74	28.50	64.75	71.76	-2.24	7.01

9:30	32.02	29.31	60.06	68.52	-2.71	8.47
10:00	32.91	29.94	56.31	65.88	-2.97	9.57
10:30	33.84	30.52	53.14	64.03	-3.32	10.89
11:00	34.46	31.00	51.59	62.12	-3.46	10.53
11:30	35.20	31.38	49.61	60.88	-3.82	11.27
12:00	35.55	31.77	48.87	59.96	-3.78	11.09
12:30	35.65	31.96	48.86	59.45	-3.69	10.59
13:00	35.79	32.13	48.45	59.09	-3.66	10.64
13:30	35.68	32.20	48.90	59.36	-3.48	10.46
14:00	35.62	32.16	49.71	59.84	-3.46	10.14
14:30	35.17	32.02	50.78	60.46	-3.15	9.68
15:00	34.88	31.98	52.06	61.30	-2.90	9.24
15:30	34.17	31.71	54.36	61.83	-2.46	7.47
16:00	33.83	31.51	55.12	62.71	-2.32	7.59
16:30	33.13	31.24	56.75	63.24	-1.89	6.49
17:00	32.26	30.65	58.53	64.52	-1.61	6.00
17:30	31.27	30.10	61.98	66.20	-1.17	4.22
18:00	30.36	29.58	64.97	67.93	-0.78	2.96
18:30	29.66	29.10	67.56	69.82	-0.56	2.26
19:00	29.15	28.70	69.44	71.69	-0.45	2.25
19:30	28.69	28.35	70.95	72.65	-0.34	1.70
20:00	28.36	28.03	72.25	73.76	-0.33	1.51
20:30	28.00	27.75	73.18	74.51	-0.25	1.32
21:00	27.71	27.49	74.26	75.41	-0.23	1.16
21:30	27.44	27.27	75.23	76.45	-0.17	1.22
22:00	27.18	27.07	76.37	77.23	-0.12	0.87
22:30	26.95	26.85	77.06	77.93	-0.10	0.87
23:00	26.74	26.67	77.91	78.72	-0.07	0.82
23:30	26.54	26.51	78.60	79.29	-0.03	0.69
0:00	26.37	26.38	79.23	79.78	0.01	0.55

Table 2 shows that the outdoor temperature (kolong) is lower than the indoor temperature; the outdoor Temperature starts to be lower than the temperature in the house, from 7.00 to 24.00. Morning. At 10,00 to 14.30, a significant temperature difference was seen, namely > 3 0C.

Likewise, with humidity, there is a significant difference of more than 10% between indoors and outdoors, from 10.30 to 14.00. Humidity is more significant than 60% outdoors, occurring from 11.00 to 14.30. while indoors from 9.30 a.m. to 17.00 p.m.





Indoor. Min 27.9^0C Max 41.1^0C	Terrace. Min 27.8^0C Max 39.3^0C	Beach. Min 10.3^0C Max 37.9^0C	Green Open Space Min 3.8^0C ,Max 26.1^0C

Fig. 4 Comparison of indoor, terrace and outdoor temperatures

From the Infra-Red Camera, in Figure 5, the Infra-Red Camera compares temperatures around 10.00 a.m. in several fishing activity rooms. Morning. At $10,^{00}$ to $14.^{30}$, a significant difference in temperature was seen, namely > 3 ^{0}C. Likewise, with humidity, there is a significant difference of more than 10% between indoor and outdoor, starting from $10.^{30}$ to $14.^{00}$. Humidity greater than 60% outdoors occurs from $11.^{00}$ to $14.^{30}$. while indoors from 9.30 am to 17.00 pm. It shows in Figure 5, a comparison of temperatures around 10.00 am in several fishing activity rooms.

5.1.1. Climate Conditions in Indoor Spaces, Terraces, Beaches, and Green Open Spaces

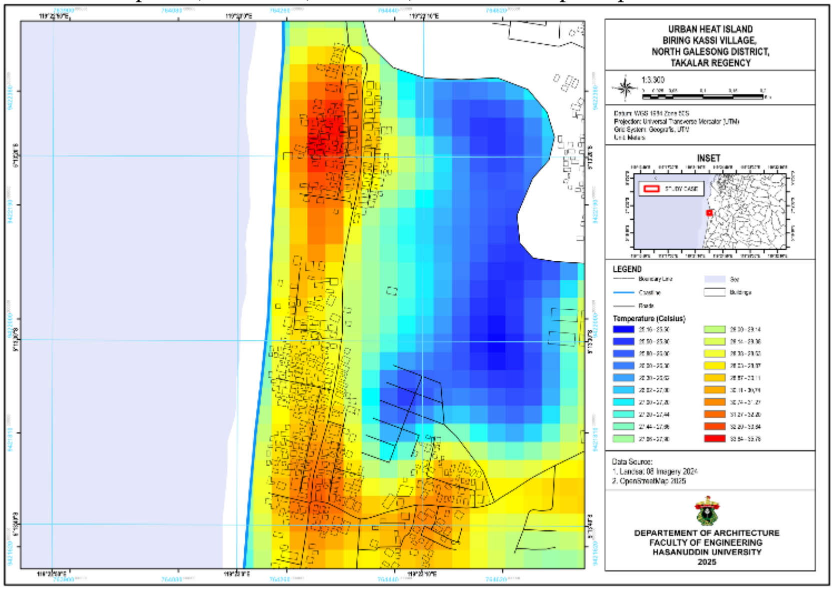


Fig. 5 Urban heat Island

The temperature conditions shown in the urban heat island image from GIS analysis with Landsat 08 Imagery 2024 source show conditions that occur during the day, where residential groups have high temperatures as a result of the use of zinc roof materials and no ceiling. Combining infrared photo data shows that the conditions inside the house are quite high during the day. Likewise, the measurement results using HOBO show the same results: the temperature inside the house is higher than in other rooms during the day. This is an indication that users of the room leave the room during the day and choose cooler rooms with more open/free air flow.

5.2. Fishermen's Clothing Choice Behavior Data

The following figure shows the place and type of activities carried out by men and the clothes worn while the activities take place.

Table 3. Correlations

		Activity Place	Activity Type	The Upper Body Clothes	The Lower Body Clothes	Age	The Reason to Take Off Clothes
Activity Place	Pearson Correlation	1	-.026	-.022	.119	.078	.082
	Sig. (2-tailed)		.731	.768	.119	.308	.345
	N	174	174	174	174	174	135
Activity Type	Pearson Correlation	-.026	1	.338**	.117	-.029	-.141
	Sig. (2-tailed)	.731		.000	.124	.701	.103
	N	174	174	174	174	174	135
The Upper Body Clothes	Pearson Correlation	-.022	.338**	1	.223**	-.191*	-.006
	Sig. (2-tailed)	.768	.000		.003	.011	.942
	N	174	174	174	174	174	135
The Lower Body	Pearson Correlation	.119	.117	.223**	1	-.370**	.158
	Sig. (2-	.119	.124	.003		.000	.068

Clothes	tailed)						
	N	174	174	174	174	174	135
Age	Pearson Correlation	.078	-.029	-.191*	-.370**	1	-.326**
	Sig. (2-tailed)	.308	.701	.011	.000		.000
	N	174	174	174	174	174	135
The Reason to Take Off Clothes	Pearson Correlation	.082	-.141	-.006	.158	-.326**	1
	Sig. (2-tailed)	.345	.103	.942	.068	.000	
	N	135	135	135	135	135	135

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
Table 3, Based on the calculation obtained:

- The correlation number between variable age and upper body clothes is -0.191. Correlation of -0.191 has the meaning that the relationship between the two variables is quite strong and unidirectional, and significant because the correlation between the two variables has a significant number of 0.011 <0.01
- The correlation number between the variable of age and the lower body clothes was - 0.370. The correlation of -0.370 has the meaning of the relationship between the two strong and unidirectional variables, and significant because the correlation of the two variables has a significant number of 0.000 <0.01
- The correlation number between the variable of age and the reason to take off clothes was -0.326. The correlation of -0.326 has the meaning of the relationship between the two strong and unidirectional variables, and is significant because the correlation of the two variables has a significant number of 0.000 <0.01
- The correlation number between the variable of upper body clothes and the lower body clothes was 0.223. The correlation of 0.223 has the meaning of the relationship between the two strong and unidirectional variables, and is significant because the correlation of the two variables has a significant value of 0.003 <0.01

The following table shows the relationship between variables that correlate.

Table 4. Activity type * age cross tabulation

Count						
		AGE				Total
		15-25	26-35	36-55	>55	
Activity Type	Work	7	8	30	26	71
	Play	16	0	0	0	16
	Relax	1	12	28	20	61
	Work And Interaction	1	0	3	3	7
	Rilex And Interaction	6	0	8	5	19
Total		31	20	69	54	174

Table 4 shows that the age group most involved in working in open space is 36-55 years, followed by> 55 years.

Table 5. The lower body clothes * age cross tabulation

		AGE				
		15-25	26-35	36-55	>55	Total
The Lower Body Clothes	Sarong	7	5	30	40	82
	Shorts	23	9	36	14	82
	Trousers	1	6	3	0	10
Total		31	20	69	54	174

Table 5 explains that those who use sarongs as much as 47.13%, among those aged > 55, more wear gloves than those of a young age, that is 48.78%, and those of a young age wear shorts (39%), and age > 55 only 8%. Only 5.75% wear trousers.

Table 6. The upper body clothes * age cross tabulation

Count		**AGE**				**Total**
		15-25	**26-35**	**36-55**	**>55**	
The Upper Body Clothes	Without Clothing	15	14	54	39	122
	T-Shirt	2	1	2	6	11
	Short Sleeve Shirt	14	5	12	8	39
	Long Sleeve Shirt	0	0	1	1	2
Total		31	20	69	54	174

Table 6 explains that fishermen usually take off clothes as much as 70%, and most of them are at the age of 36-55 and > 55 years, which is as much as 53.45%, T-shirt 6.32%, and short sleeve shirts 22.41%.

Table 7. Activity type * the upper body clothes cross tabulation count

		The Upper Body Clothes				
		Without Clothing	**T-Shirt**	**Short Sleeve Shirt**	**Long Sleeve Shirt**	**Total**
Acti vity Type	Work	59	6	5	1	71
	Play	10	0	6	0	16
	Relax	44	3	13	1	61
	Work And Interaction	3	1	3	0	7
	Rilex And Interaction	6	1	12	0	19
Total		122	1 1	39	2	174

Table 7 explains that people who work and relax generally do not wear clothes of 59%. And those who use the long arm are guests/visitors.

Table 8. The reason to take off clothes * age cross tabulation count

		AGE				**Total**
		15-25	**26-35**	**36-55**	**>55**	
The Reason To Take Off Clothes	Hot	2	5	17	35	59
	Sweat	9	4	29	6	48
	Sticky	3	2	4	0	9
	Itchy	0	1	2	0	3
	Habit	0	0	3	4	7
	More Flexible	4	3	1	1	9
Total		18	15	56	46	135

Table 8 explains that men aged> 55 years generally take off clothes because they feel hot (25.9%), ages 15-55 (17.7%) aged 15-55 years because they feel sweaty (31.1%), and age> 55 is 4.4%.

From 108 observations involving 174 men, based on a questionnaire that was submitted to those who take off clothes to find out the reason for the attitude to take off clothes on the upper body, is that they feel hot and sweaty during the day; the other answers are less significant than that attitude. Figure 6 shows the places and types of activities carried out by men. It can be seen that their upper body is unclothed and left open so that free air can touch the surface of their skin and body, and the lower part of the body is covered with a sarong or shorts. If anyone is fully clothed, then they are guests. People take off their clothes and wear sarongs for various reasons, such as heat, sweat, itching, and habit.

Fig. 6 Places, types of activities and fishermen's outfits when on land

The following figure shows the place and type of activities carried out by men and the clothes worn.

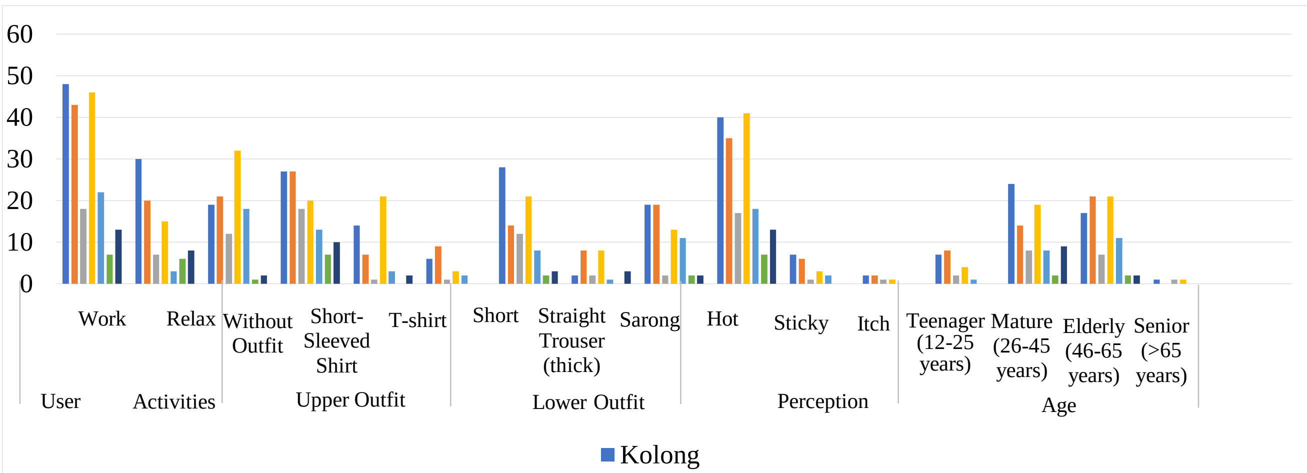


Fig. 7 User activities condition

The figure shows the percentage of the activity place, the type of activity, the type of outfit used, the perception of the use of the outfit, and the age of the room users. The data shows that fishers generally use outdoor space (kolong 25%, house yard 21%, terrace 9%, green open space 23%, guard post 11%, and beach 7%) for activities, and only about 3 % use indoor space in activities during the day. The type of activity they do is 55% working, and the remaining 45% resting/relaxing. In activities, 60.8% do not put on outfits on the upper body, 24.7% only wear short-sleeved shirts/t-shirts, and the remaining 11.8% wear T-shirts. For the lower body outfit, 46.9% wore shorts, 36.6% wore sarongs, and the remaining 14.4% wore trousers. The reason for using the room was 86.6% due to heat, 10.3% sticky feelings, 3.1% itchy feelings, and all ages chose. Kolong, the yard, and the green open space are activity places.

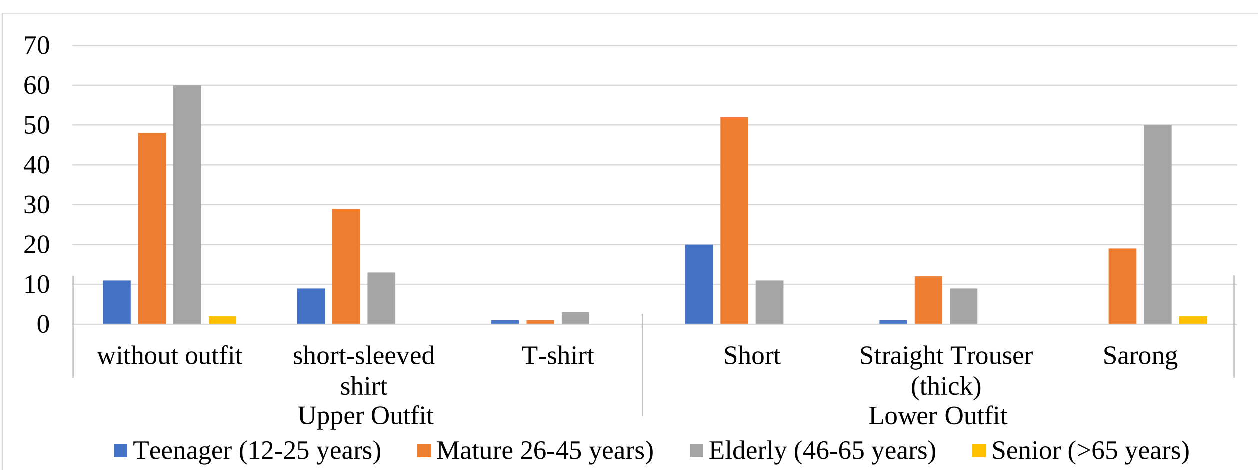


Fig. 8 Age and outfit

Older people (46-65 years) are mostly without an outfit on the upper part of the body, while the lower part of the body uses a sarong more. While adults (26-45 years) mostly use short-sleeved shirts and shorts.

Table 9. Results of clothing insulation values

	Clothing Type	Average value (Clo)	Total Clo
Upper outfit	No outfit	0.00	0.27
	T-shirt	0.06	
	Short-Sleeved shirt	0.19	
Lower outfit	Walking short	0.08	0.25
	Straight trouser(thin)	0.15	
	Sandals	0.02	

Table 9 illustrates the total value of clothing insulation generally used by fishermen for upper body clothing, with a total of 27 clo, and for lower body clothing, with 25 clo.

6. Discussion

6.1. Fishermen's Adaptive Behavior to Extreme Temperatures

Figure 7 illustrates that fishermen predominantly utilize outdoor spaces for their daily activities, reflecting the central role of open areas in supporting their livelihood practices, that fishermen primarily utilize outdoor spaces for their activities: 25% use the kolong (space beneath the house), 21% the yard, 9% the terrace, 23% green open spaces, 11% the guard post, and 7% the beach. Only 3% of activities occur indoors. Approximately 55% of these activities are work-related, while the remaining 45% involve resting or relaxing.

Most activities commence after fishermen return from the sea around 10:00 AM, by which time indoor temperatures reach 32.91°C. Comparatively, outdoor areas such as the kolong exhibit lower temperatures, averaging 29.94°C—a difference of 2.97°C. At peak temperatures, the indoor environment reaches 35.68°C, while outdoor areas under shade remain at 32.20°C, creating a difference of 3.66°C (Table 2; Figures 3, 4, 5, and 6).

Indoor spaces are often directly beneath roofs without thermal insulation, making them highly susceptible to heat accumulation. In tropical climates, the roof significantly influences indoor climate conditions, often serving as the primary source of heat gain in buildings.

According to Majed Abuseif and Zhonghua Gou [35], the roof plays a critical role in building sustainability by absorbing thermal energy in hot climates. Studies by Remon Lapisa et al [36], Ali Habeeb Askar et al. [37], and Ibrahim et al. [38] reveal that roof angles affect thermal comfort, with low-slope roofs exposing interiors to greater solar radiation.

By contrast, the kolong, a shaded and ventilated area beneath raised houses, provides natural airflow, enhancing outdoor thermal comfort. Figure 7 further highlights a preference for shaded, open spaces with free airflow, such as the kolong (25%), green open spaces (23%), and house yards (21%). Figure 5 corroborates these findings, showing that indoor temperatures are consistently higher than outdoor shaded areas. Average temperatures inside the house reach 34.5°C, compared to 33.55°C on terraces, 24.1°C on beaches, and 15°C in green open spaces. At 10:00 AM, indoor conditions are clearly uncomfortable for activities.

Several standards support these findings. ASHRAE [3] suggests that thermal comfort in humid tropical climates occurs within a temperature range of 23.3°C–26.1°C and 50%-60% humidity. Indonesia's National Standard (SNI) specifies a comfort range of 20.5°C-27.1°C with 40%-60% humidity, while the Indonesian Ministry of Health recommends a room temperature of 18°C-30°C with 40%-70% humidity. Westerberg [39] and Battisti & Santucci [40] emphasize the importance of weather conditions for outdoor activity quality. Additionally, wind plays a significant role in enhancing outdoor thermal comfort by promoting sweat evaporation, as noted by Stathopoulos et al. [41] and Sangkertadi [42].

The study area exceeds the upper thermal comfort limits of 30°C, confirming the discomfort of indoor environments. Elnabawi and Hamza [21] stress the significant role of microclimates in shaping outdoor space use, while Zacharias et al. [22] note that at temperatures above 20°C, people tend to seek shade or avoid direct sunlight. Tsang Huang [23] and Katzschner [20] similarly observe that high temperatures encourage static activities in shaded areas.

Figure 7 also indicates that 55% of outdoor activities involve work. Comfortable conditions are essential for productivity, as discomfort in the workplace hinders performance [43]. Thermal comfort directly impacts physical and cognitive functioning, with unsafe behavior and decreased productivity resulting from heat exposure. Bell and Baro [44] argue that exposure to heat reduces the willingness to work, while shading devices significantly improve comfort and productivity. Barbhuiya and Barbhuiya [45] highlight that thermally uncomfortable environments decrease performance and productivity. Rising temperatures reduce worker efficiency, making shading devices a critical solution. The kolong, as a shaded and ventilated space, provides a conducive environment with effective air circulation. Moving air is crucial for thermal comfort in tropical climates [46, 48].

6.2. The Role of Clothing in Regulating Fishermen's Thermal Comfort

Figure 8 shows the clothing preferences of fishermen during their activities. On the upper body, 64.8% do not wear any clothing, 24.7% wear short-sleeved shirts, and 11.8%

wear T-shirts. For the lower body, 46.9% wear shorts, 36.6% wear sarongs, and 14.4% wear trousers. The primary reason for using outdoor spaces is heat, cited by 86.6% of respondents, while 10.3% report feeling sticky and 3.1% experience itching. Fishermen across all age groups generally prefer spaces such as the kolong, yards, and green open areas for their activities (Figure 7). Tables 5, 6, and 7 provide more details on how age and work type influence clothing choices, while Table 8 outlines the reasons behind these clothing decisions. Figure 6 further illustrates that fishermen typically wear minimal clothing, mostly covering only the lower part of their bodies with a sarong or shorts. This pattern reflects the daily behavior of fishing communities in coastal settlements.

Hot climates can induce heat stress, a condition resulting from the interaction of environmental factors, physical activity levels, and the thermal properties of clothing [49, 50]. Researchers such as George Havenith [51] and Narihiko Kondo et al. [52] suggest that the human thermoregulatory system adapts to varying environmental conditions, and behaviors such as removing clothing help maintain comfort. Fishermen in this study, for example, adapt to extreme heat by reducing their clothing to stay cool (Figure 6).

The role of clothing in climate adaptation has been explored in various studies. Y. Hu et al. [53] examined how people in England responded to heat waves, recommending measures such as reducing clothing, using fans to increase air movement, seeking shade, and taking cold showers to manage extreme heat. Karyono [43] found that people in tropical climates tend to have body temperatures 0.3°C–0.4°C higher than those in temperate climates. Clothing insulation is a key factor in adapting to thermal environments, with individuals adjusting their clothing to regulate body temperature [54].

ASHRAE [3] notes that clothing's insulating effect significantly influences thermal comfort by reducing the release of body heat. Sahta et al. [55] explain that the thermal comfort of clothing is related to the body's thermal balance and response to environmental conditions. Clothing insulation is typically measured in Clo units, with 0.5 Clo being the threshold for comfort. Table 9 shows that the insulation value of the fishermen's clothing is approximately 0.27 Clo for both the upper and lower garments, which is below the comfort threshold. However, Tetsu Kubota et al. [6] found that subjects in outdoor temperatures of 29°C remained comfortable while wearing clothing with insulation values between 0.4 and 1.01 Clo, indicating that the fishermen's clothing is still within an acceptable comfort range for their activities. Wearing loose-fitting clothing, such as sarongs (36.6%), facilitates air circulation and reduces skin friction, which is particularly beneficial when sweating.

The relationship between temperature and workplace productivity is also influenced by clothing. Comfortable clothing promotes ease of movement, improving work quality and output. Sehgal [56] asserts that the optimal temperature for productivity varies based on individual body conditions. Older individuals, whose body temperature tends to decrease with age [57], may be expected to wear more clothing for warmth. However, in coastal areas, older fishermen typically wear minimal clothing on the upper body and more sarongs (loose, thin cotton garments) on the lower body (Figures 6, 8; Tables 5, 6). This preference is driven not only by adaptation to hot conditions but also by long-standing habits formed over years of living in the region. Previous behavior is a strong predictor of future behavior [58].

6.3. Recommendations to Enhance Fishermen's Comfort and Productivity

Based on the discussions about fishermen's adaptive behaviors to extreme temperatures, several strategies can be recommended to improve their comfort and productivity in harsh coastal environments:

1. Utilization of Spaces with Optimal Air Circulation
- Enhancing Under-House Areas and Green Open Spaces: Recognizing that under-house spaces and green open areas, such as yards, are primary choices for fishermen's activities, these spaces should be optimized by providing better shading. Adding canopies or structures to enhance cooling effects and air circulation will be highly beneficial.
- Incorporating Air-Purifying Plants: Planting shade-providing or air-purifying vegetation around homes and activity areas can improve air quality and create a more comfortable environment.

2. Temperature-Sensitive Building Design
- Thermal Insulation for Roofs: As findings show that non-insulated roofs contribute to high indoor temperatures, roofs should be designed to minimize heat absorption. Reflective materials or the installation of ceilings can effectively reduce solar radiation and indoor heat.
- Improved Ventilation: Enhancing ventilation through additional air vents or cross-ventilation systems can significantly improve airflow, lowering indoor temperatures.

3. Use of Shading Devices and Cooling Structures
- Shading Installations: Considering the high outdoor temperatures, especially in under-house spaces and yards, shading devices such as curtains, canopies, or larger trees around fishermen's homes and work areas can help reduce direct sunlight exposure and keep temperatures cooler.
- Creating Shaded Work Areas: Leveraging natural vegetation or trees to establish shaded zones in fishermen's workplaces can improve comfort and alleviate heat-induced fatigue.

4. Thermally Comfortable Clothing
- Climate-Appropriate Apparel: Given fishermen's preference for loose and lightweight clothing, recommending attire made of breathable materials like

cotton that wick away sweat can enhance comfort in hot conditions.

- Sun Protection Gear: In addition to lightweight clothing, the use of sun-protective items such as hats or umbrellas can reduce direct sun exposure, mitigating health risks like dehydration and heat-related illnesses.

5. Raising Awareness of Health and Safety Risks

- Education on Health Hazards of Extreme Temperatures: Providing training on health risks like heat stroke, dehydration, and heat exhaustion, along with strategies to prevent and manage them, is crucial. This should include guidance on proper hydration and rest during work.
- Provision of Comfortable Rest Facilities: Establishing shaded rest areas with access to drinking water can help fishermen avoid heat exhaustion while working under intense sunlight.

This paper aims to understand and optimize thermal adaptation strategies and space usage in coastal fishing communities residing in humid tropical climates. The focus is on enhancing thermal comfort through environmental design that promotes air circulation and shade, as well as the selection of appropriate clothing. These factors are essential for supporting the health and productivity of fishermen. By implementing these strategies, it is anticipated that fishermen will be better equipped to adapt to extreme coastal conditions, improve their work comfort, and maintain both their health and productivity.

7. Conclusion

This paper provides a comprehensive exploration of thermal adaptation strategies and spatial behavior in coastal fishermen communities living in humid tropical climates. The findings highlight the significant role of environmental factors, such as air circulation, shade, and appropriate clothing, in enhancing thermal comfort and supporting the well-being and productivity of fishermen in extreme conditions.

The study reveals that fishermen predominantly use outdoor spaces, such as the kolong (space beneath the house), yards, and green open areas, for their activities, as these spaces offer lower temperatures and better airflow compared to indoor environments. This preference for shaded and ventilated spaces underscores the critical need for adaptive building designs that prioritize natural ventilation and minimize heat absorption, particularly through the use of thermal insulation for roofs and the introduction of shading devices [28, 35].

Furthermore, clothing plays a pivotal role in managing thermal comfort, with fishermen opting for minimal, loose-fitting attire, such as sarongs and shorts, to reduce heat stress. This behavior is consistent with findings from studies on the human thermoregulatory system, which show that reducing clothing insulation can significantly improve comfort in hot environments [51, 52]. The insulation value of the fishermen's clothing, although below the comfort threshold, remains within an acceptable range for the tropical climate, further highlighting the adaptability of the fishermen's clothing choices [6, 3]

The integration of these adaptive behaviors, both in terms of spatial preferences and clothing, is essential in promoting resilience within coastal fishing communities. These strategies not only improve thermal comfort but also contribute to enhancing productivity and preventing heat-related health issues, such as heat exhaustion and dehydration [43, 45]

To optimize these adaptive strategies, this paper recommends enhancing outdoor spaces with better shading, improving building design to reduce heat gain, and encouraging the use of climate-appropriate clothing. Additionally, raising awareness about the health risks associated with extreme temperatures and providing comfortable rest facilities are essential steps to mitigate heat stress.

Ultimately, the findings emphasize the importance of integrating environmental and behavioral adaptation strategies to create sustainable, comfortable, and productive living and working conditions for coastal fishermen in tropical climates. These strategies address immediate thermal discomfort and contribute to long-term resilience against the challenges posed by extreme climate conditions.

Acknowledgment

The author would like to express sincere gratitude to the Faculty of Engineering, Hasanuddin University, for the academic support and resources provided throughout the course of this research. Special thanks are extended to the local fishing communities in Galesong Utara, Takalar, whose participation and insights were invaluable to this study.

References

[1] Ewelina Dec, Bożena Babiarz, and Robert Sekret, "Analysis of Temperature, Air Humidity and Wind Conditions for the Needs of Outdoor Thermal Comfort," *E3S Web of Conferences*, vol. 44, pp. 1-9, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[2] Thomas Alsmo, and Catharina Alsmo, "Ventilation and Relative Humidity in Swedish Buildings," *Journal of Environmental Protection*, vol. 5, no. 11, pp. 1022-1036, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[3] ANSI/ASHRAE/IES Standard 90.1-2010, Energy Standard for Buildings Except Low-Rise Residential Buildings, I-P Edition, Standard. 2012. [Online]. Available: https://www.usailighting.com/stuff/contentmgr/files/1/b90ce247855d0f17438484c003877338/misc/ashrae_90_1_2010.pdf

[4] R. Tuğrul Oğulata, "The Effect of Thermal Insulation of Clothing on Human Thermal Comfort," *Fibres and Textiles in Eastern Europe*, vol. 15, no. 2, pp. 67-72, 2007. [Google Scholar]

[5] JuYoun Kwon, and Jeongwha Choi, "The Relationship between Environmental Temperature and Clothing Insulation Across a Year," *International Journal of Biometeorology*, vol. 56, pp. 887-893, 2012. [CrossRef] [Google Scholar] [Publisher Link]

[6] Tetsu Kubota, Doris Toe Hooi Chyee, and Supian Ahmad, "The Effects of Night Ventilation Technique on Indoor Thermal Environment for Residential Buildings in Hot-Humid Climate of Malaysia," *Energy and Buildings*, vol. 41, no. 8, pp. 829-839, 2009. [CrossRef] [Google Scholar] [Publisher Link]

[7] Manoj Kumar Singh, Sadhan Mahapatra, and S.K. Atreya, "Thermal Performance Study and Evaluation of Comfort Temperatures in Vernacular Buildings of North-East India," *Building and Environment*, vol. 45, no. 2, pp. 320-329, 2010. [CrossRef] [Google Scholar] [Publisher Link]

[8] F. Nicol, and M. Humphreys, "Maximum Temperatures in Buildings to Avoid Heat Discomfort," *International Conference "Passive and Low Energy Cooling 219 for the Built Environment*," Santorini, Greece, pp. 219-224, 2005. [Google Scholar] [Publisher Link]

[9] Victor Adetunji Arowoiya et al., "Influence of Thermal Comfort on Energy Consumption for Building Occupants: The Current State of the Art," *Buildings*, vol. 14, no. 5, pp. 1-28, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[10] Amos Rapoport, *Culture, Architecture, and Design*, Locke Science Publishing Company, 2005. [Google Scholar] [Publisher Link]

[11] Pedro Moscoso-García, and Felipe Quesada-Molina, "Analysis of Passive Strategies in Traditional Vernacular Architecture," *Buildings*, vol. 13, no. 8, pp. 1-23, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[12] Alexandra Cojocaru, and Dorina Nicolina Isopescu, "Passive Strategies of Vernacular Architecture for Energy Efficiency," *Bulletin of the Polytechnic Institute of Iași. Construction, Architecture Section*, vol. 67, no. 2, pp. 33-44, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[13] Wannapol Sadakorn et al., "Assessing Thermal Comfort in Hot and Humid (Tropical) Climates: Urban Outdoor and Semi-Outdoor Conditions in Waiting Areas of Railway Stations," *Building and Environment*, vol. 267, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[14] Wenjie Song, and John Kaiser Calautit, "Inclusive Comfort: A Review of Techniques for Monitoring Thermal Comfort Among Individuals with the Inability to Provide Accurate Subjective Feedback," *Building and Environment*, vol. 257, pp. 1-25, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[15] Camila Tavares Pereira, Érico Masiero, and Vandoir Bourscheidt, "Socio-Spatial Inequality and its Relationship to Thermal (dis) Comfort in Two Major Local Climate Zones in a Tropical Coastal City," *International Journal of Biometeorology*, vol. 65, pp. 1177-1187, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[16] "*Chapter 11: Weather and Climate Extreme Events in a Changing Climate*," IPCC Sixth Assessment Report, pp. 1513-1765, 2021. [Google Scholar] [Publisher Link]

[17] Pir Mohammad, and Qihao Weng, "Asian Heat Stress Variations in a Changing Climate: Implications for Disproportionate Urban and Rural Population Exposure," *Habitat International*, vol. 156, pp. 1-15, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[18] Hom B. Rijal, Michael Humphreys, and Fergus Nicol, "Adaptive Thermal Comfort in Japanese Houses during the Summer Season: Behavioral Adaptation and the Effect of Humidity," *Buildings*, vol. 5, no. 3, pp. 1037-1054, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[19] David P. Wyon, I.B. Andersen, and Gunnar R. Lundqvist, "The Effects of Moderate Heat Stress on Mental Performance," *Scandinavian Journal of Work, Environment & Health*, vol. 5, no. 4, pp. 352-361, 1979. [CrossRef] [Google Scholar] [Publisher Link]

[20] Lutz Katzschner, "Behaviour of People in Open Spaces in Dependence of Thermal Comfort Conditions," *PLEA2006 - The 23rd Conference on Passive and Low Energy Architecture*, Geneva, Switzerland, pp. 1-5, 2006. [Google Scholar] [Publisher Link]

[21] Mohamed H. Elnabawi, and Neveen Hamza, "Behavioural Perspectives of Outdoor Thermal Comfort in Urban Areas: A Critical Review," *Atmosphere*, vol. 11, no. 1, pp. 1-23, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[22] John Zacharias, Ted Stathopoulos, and Hanqing Wu, "Microclimate and Downtown Open Space Activity," *Environment and Behavior*, vol. 33, no. 2, pp. 296-315, 2001. [CrossRef] [Google Scholar] [Publisher Link]

[23] Kuo-Tsang Huang, Tzu-Ping Lin, and Hsiao-Chi Lien, "Investigating Thermal Comfort and User Behaviors in Outdoor Spaces: A Seasonal and Spatial Perspective," *Advances in Meteorology*, vol. 2015, no. 1, pp. 1-11, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[24] Thermal Environmental Conditions for Human Occupancy, ANSI/ASHRAE Addendum j to ANSI/ASHRAE Standard 55-2020. [Online]. Available: https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/55_2020_j_20231031.pdf

[25] S.D. Bradshaw, and A.R. Main, "Behavioural Attitudes and Regulation of Temperature in Amphibolurus Lizards," *Journal of Zoology*, vol. 154, no. 2, pp. 193-221, 1968. [CrossRef] [Google Scholar] [Publisher Link]

[26] Sally Shahzad et al., "Visual Thermal Landscaping (VTL) Model: A Qualitative Thermal Comfort Approach based on the Context to Balance Energy and Comfort," *Energy Procedia*, vol. 158, pp. 3119-3124, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[27] Andi Ahmad Fauzan Bachtiar et al., "Model for Determining Thermal Comfort in Fisherman's Residential Areas on Coasts with Humid Tropical Climates," *Civil Engineering and Architecture*, vol. 12, no. 5, pp. 3545-3561, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[28] Zhonghua Gou et al., "An Investigation of Thermal Comfort and Adaptive Behaviors in Naturally Ventilated Residential Buildings in Tropical Climates: A Pilot Study," *Buildings*, vol. 8, no. 1, pp. 1-17, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[29] Michele De Carli et al., "People's Clothing Behaviour according to External Weather and Indoor Environment," *Building and Environment*, vol. 42, no. 12, pp. 3965-3973, 2007. [CrossRef] [Google Scholar] [Publisher Link]

[30] Craig Morgan, and Richard de Dear, "Weather, Clothing and Thermal Adaptation to Indoor Climate," *Climate Research*, vol. 24, no. 3, pp. 267-284, 2003. [CrossRef] [Google Scholar] [Publisher Link]

[31] Hélder Silva Lopes et al., "Clothing and Outdoor Thermal Comfort (OTC) in Tourist Environments: A Case Study from Porto (Portugal)," *International Journal of Biometeorology*, vol. 68, pp. 2333-2355, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[32] Jayesh Dashrath Khaire, Leticia Ortega Madrigal, and Begona Serrano Lanzarote, "Outdoor Thermal Comfort in Built Environment: A Review of Studies in India," *Energy and Buildings*, vol. 303, pp. 1-16, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[33] Lazar Mandić et al., "A Systematic Review of Outdoor Thermal Comfort Studies for the Urban (Re)Design of City Squares," *Sustainability*, vol. 16, no. 12, pp. 1-45, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[34] Husein Umar, *Marketing Research and Consumer Behavior*, Gramedia Pustaka Utama, 2002. [Google Scholar] [Publisher Link]

[35] Majed Abuseif, and Zhonghua Gou, "A Review of Roofing Methods: Construction Features, Heat Reduction, Payback Period and Climatic Responsiveness," *Energies*, vol. 11, no. 11, pp. 1-22, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[36] Remon Lapisa et al., "Numerical Analysis of the Roof Slope Effect on the Building Thermal Comfort and the Need for Roofing Materials in Tropical Area," *International Journal on Advance Science Engineering Information Technology*, vol. 12, no. 6, pp. 2556-2562, 2022. [CrossRef] [Publisher Link]

[37] Ali Habeeb Askar, Issa Omle, and Endre Kovács, "The Role of Roof Angle and Geographic Location on the Thermal Performance of Buildings," *International Journal of Thermofluids*, vol. 27, pp. 1-18, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[38] S.H. Ibrahim et al., "Study on the Effect of the Roof Opening on the Temperature Underneath," *International Journal of Applied Engineering Research*, vol. 9, no. 23, pp. 20099-20110, 2014. [Google Scholar]

[39] Ulla Westerberg, "Climate and the Use of Urban Public Spaces," *Plea2004 - The 21th Conference on Passive and Low Energy Architecture*, Eindhoven, The Netherlands, pp. 1-6, 2004. [Google Scholar] [Publisher Link]

[40] Alessandra Battisti, and Daniele Santucci, *Activating Public Space - An Approach for Climate Change Mitigation*, Technical University of Munich, Faculty of Architecture, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[41] Theodore Stathopoulos, Hanqing Wu, and John Zacharias, "Outdoor Human Comfort in an Urban Climate," *Building and Environment*, vol. 39, no. 3, pp. 297-305, 2004. [CrossRef] [Google Scholar] [Publisher Link]

[42] Sangkertadi Sangkertadi, "The Role of Wind Velocity on Increasing Human Thermal Comfort in Hot and Humid Environment," *Journal of Humans and Environment*, vol. 13, no. 2, pp. 71-89, 2006. [Publisher Link]

[43] Kanisius Karyono et al., "The Adaptive Thermal Comfort Review from the 1920s, the Present, and the Future," *Developments in the Built Environment*, vol. 4, pp. 1-12, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[44] Paul A. Bell, and Robert A. Baron, "Environmental Influences on Attraction: Effects of Heat, Attitude Similarity, and Personal Evaluations," *Bulletin of the Psychonomic Society*, vol. 4, pp. 479-481, 1974. [CrossRef] [Google Scholar] [Publisher Link]

[45] Saadia Barbhuiya, Salim Barbhuiya, and Hamid Nikraz, "Adaptation to the Future Climate: A Low Carbon Building Design Challenge," *Procedia Engineering*, vol. 51, pp. 194-199, 2013. [CrossRef] [Google Scholar] [Publisher Link]

[46] Naja Aqilah, Hom Bahadur Rijal, and S.A. Zaki, "Indoor Thermal Environment and Effect of Air Movement on Comfort Temperature in Malaysian Naturally Ventilated Dwellings," *Journal of Building Engineering*, vol. 104, pp. 1-17, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[47] Edward Arens et al., "Moving Air for Comfort," *ASHRAE Journal*, pp. 18-28, 2009. [Google Scholar] [Publisher Link]

[48] T. Stathopoulos, "Wind and Comfort," 5th *European and African Conference on Wind Engineering, EACWE 5, Proceedings*, 2009. [Google Scholar]

[49] Michael N. Sawka, C. Bruce Wenger, and Kent B. Pandolf, *Thermoregulatory Responses to Acute Exercise-Heat Stress and Heat Acclimation*, Handbook of Physiology, Environmental Physiology, pp. 157-185, 2010. [CrossRef] [Google Scholar] [Publisher Link]

[50] J.D. Périard, S. Racinais, and M.N. Sawka, "Adaptations and Mechanisms of Human Heat Acclimation: Applications for Competitive Athletes and Sports," *Scandinavian Journal of Medicine & Science in Sports*, vol. 25, no. S1, pp. 20-38, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[51] George Havenith, "Interaction of Clothing and Thermoregulation," *Exogenous Dermatology*, vol. 1, no. 5, pp. 221-230, 2002. [CrossRef] [Google Scholar] [Publisher Link]

[52] Narihiko Kondo et al., "Thermoregulatory Adaptation in Humans and its Modifying Factors," *Global Environmental Research*, vol. 13, no. 1, pp. 35-41, 2009. [Google Scholar] [Publisher Link]

[53] Y. Hu et al., "Neural Control of Sweat Secretion: A Review," *British Journal of Dermatology*, vol. 178, no. 6, pp. 1246-1256, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[54] Henry Feriadi, and Wong Nyuk Hien, "Modelling Thermal Comfort for Tropics Using Fuzzy Logic," *Eighth International IBPSA Conference*, Eindhoven, Netherlands, pp. 323-330, 2003. [Google Scholar] [Publisher Link]

[55] I. Sahta et al., "The Control of Human Thermal Comfort by the Smart Clothing," *SHS Web of Conferences: 4th International Interdisciplinary Scientific Conference Society, Health, Welfare*, vol. 10, pp. 1-7, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[56] Shruti Sehgal, "Relationship between Work Environment and Productivity," *International Journal of Engineering Research and Applications*, vol. 2, no. 4, pp. 1992-1995, 2012. [Google Scholar] [Publisher Link]

[57] Ülkü Yapucu Güneş, and Ayten Zaybak, "Does the Body Temperature Change in Older People?," *Journal of Clinical Nursing*, vol. 17, no. 17, pp. 2284-2287, 2008. [CrossRef] [Google Scholar] [Publisher Link]

[58] Leah DeSole, *Eating Disorders and Mindfulness: Exploring Alternative Approaches to Treatment*, Taylor & Francis, pp. 1-176, 2014. [Google Scholar] [Publisher Link]