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Design and Evaluation of a Multichannel Information Architecture for PET-Based Thermal Comfort Dissemination in DKI Jakarta

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Urban heat exposure in tropical megacities has intensified, yet public weather services still communicate conditions as separate meteorological parameters that do not describe the thermal load experienced by the human body. The Physiological Equivalent Temperature (PET) index addresses this limitation, but most PET studies conclude as analyses, maps, or datasets rather than services reaching the public. This study designs and evaluates a multichannel information architecture for delivering PET-based thermal comfort information at subdistrict resolution to the general public in DKI Jakarta. Hourly ECMWF Integrated Forecasting System forecasts were obtained through an open weather data service for 267 subdistricts across 44 districts and six administrative cities, from which mean radiant temperature and PET were computed and classified using a nine-class tropical scheme. The information was organised into three separated nodes in which 2,448 precomputed aggregate records accompany 12,816 hourly subdistrict records, delivered through an interactive dashboard and a scheduled messaging summary. Precomputation adds 9.3 percent to stored payload but reduces the data read to render the aggregate layers from 3,053.2 KB to 5.90 KB, a factor of 518. All twelve functional test scenarios performed as expected, and the mean usability score across twelve respondents reached 85.2, well above the reported average. Separating aggregation levels and pairing a pull channel with a push channel makes high resolution thermal comfort information navigable for non-expert users.
Keywords: Information architecture, Information dissemination, Dashboard, Physiological equivalent temperature, Thermal comfort.

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1. Introduction

Thermal exposure in tropical urban areas has increased steadily. Land surface temperature analyses identify a persistent urban heat island over the Jakarta metropolitan area whose intensity and extent have grown with built-up expansion, a pattern repeated across the major cities of Java over two decades [1], [2]. The burden is unevenly distributed, since neighbourhoods with limited vegetation cover face greater exposure than better served areas, and it is projected to grow as widespread heat stress becomes normal across Southeast Asia, while regional adaptation responses remain fragmented [3], [4], [5].

Public weather services nevertheless communicate conditions as separate parameters such as air temperature, humidity, and wind speed, none of which describes the thermal load experienced by the body. Residents are left to combine these parameters themselves, which is precisely the interpretive step a thermal index is designed to remove.

This study addresses how information based on the Physiological Equivalent Temperature (PET) can be organised and delivered rather than how the index is computed. Its scope covers DKI Jakarta at subdistrict resolution, uses open forecast data with a 48-hour horizon, and reaches the general public through an

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interactive web dashboard and a scheduled messaging summary. Long term operational reliability and the mechanics of data processing fall outside this scope.

The study therefore pursues three objectives, namely to design a hierarchical information architecture for PET data at subdistrict resolution, to implement a multichannel dissemination strategy pairing an exploratory dashboard with a scheduled summary, and to evaluate the resulting delivery through functional testing and a usability assessment.

2. Literature Review and Problem Statement

PET is a thermal index derived from the human energy balance, expressing air temperature, humidity, wind speed, and radiation as a single equivalent temperature, and a recent review places it among the indices most frequently applied outdoors in tropical and subtropical regions [6]. Comparative evaluations of outdoor thermal indices report the same position for PET across climatic settings [7]. Because thermal adaptation raises the neutral range in tropical populations, temperate classifications cannot be transferred directly. Lin and Matzarakis [8] established a nine-class scheme for tropical and subtropical conditions in which the neutral range lies between 26 and 30 °C, roughly seven to eight degrees above the temperate equivalent, and that scheme is adopted here.

The results of such studies nevertheless remain within the research domain as analyses, maps, or datasets rather than services the public can consult, as in recent Indonesian assessments that conclude with design recommendations rather than public delivery [9], and work on public information dashboards reveals a parallel weakness in delivery. A scoping review found usability assessment reported in fewer than a third of cases and information on how users were expected to learn of a dashboard absent in three quarters of them [10]. An expert appraisal identified the features that make such tools actionable, among them spatial resolution sufficient for local assessment and disaggregation allowing risk to be evaluated at a relevant level, criteria articulated within public health and not applied to thermal comfort information [11].

The gap therefore lies between the technical output of biometeorological computation and the comprehension of a non-expert audience. The question is not how PET should be calculated, since established methods exist, but how it should be structured and delivered so that residents can locate the condition relevant to them without specialist knowledge. This yields the research question. How can a multichannel information architecture deliver PET-based thermal comfort information effectively to the general public at subdistrict resolution in DKI Jakarta?

3. Method

Data Source and Preprocessing

Hourly forecasts were obtained from an open weather data service redistributing output from the ECMWF Integrated Forecasting System at approximately nine-kilometre resolution [12]. Four variables were retrieved per location, namely air temperature and dew point temperature at two metres, wind speed at ten metres, and total cloud cover. Boundaries and centroid coordinates for the 267 subdistricts were obtained from the provincial spatial data service. Table 1 summarises the specification and coverage.
Relative humidity (RH) at two metres is not supplied directly, so it was derived from air temperature and dew point temperature using the Magnus form, given in Equation 1 [13], [14].

$$RH = 100 \exp\left(\frac{aT_d}{b + T_d} - \frac{aT_a}{b + T_a}\right) \quad (1)$$

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Here T_a is air temperature and T_d is dew point temperature, both in °C, with a of 17.625 and b of 243.04 °C. Cloud cover was then converted to oktas and wind speed reduced from ten metres to the 1.1 metre reference height.

Table 1. Data source, retrieved variables, and study coverage

Aspect	Specification
Forecast source	ECMWF Integrated Forecasting System, accessed through an open weather data service
Model resolution	Approximately 9 km
Forecast horizon	48 hours at hourly resolution
Variables retrieved	Air temperature at 2 m, dew point temperature at 2 m, wind speed at 10 m, total cloud cover
Derived variables	Relative humidity at 2 m, cloud cover in oktas, wind speed at 1.1 m
Boundary data	Subdistrict boundaries and centroid coordinates from the provincial spatial data service
Spatial coverage	267 subdistricts, 44 districts, 6 administrative cities
Time reference	Western Indonesia Time (UTC+7)
Computation library	biometeo 0.5.2, a Python implementation of human biometeorological indices

Only four variables are therefore requested, because the remaining inputs are derived rather than retrieved. This matters at scale, since the same query is issued for 267 locations in every forecast cycle. After preprocessing, air temperature, relative humidity, wind speed at 1.1 metres, and cloud cover in oktas together form the complete input to the index computation, which consequently relies on forecast output and static location metadata alone, without any observational measurement from within the study area.

Index Computation and Classification

Mean radiant temperature ($\mathrm{T_{mrt}}$) and PET were computed with version 0.5.2 of the biometeo library [15]. $\mathrm{T_{mrt}}$ was estimated from solar geometry, atmospheric attenuation, and cloud cover using location coordinates, elevation, and local time, and PET was then computed from air temperature, vapour pressure, $\mathrm{T_{mrt}}$, and wind speed at 1.1 metres. Computation follows the standard reference subject defined in the library, namely 0.9 clo clothing insulation, 80 W metabolic activity, 1.75 m height, 75 kg body mass, 35 years of age, male sex, and standing posture, held constant so that differences between locations reflect meteorological conditions alone. Values were classified using the nine-class tropical and subtropical scheme in Table 2, applied on the provider side so that every delivered value already carries its class label.

Table 2. PET classification for tropical and subtropical conditions

PET range (°C)	Thermal perception class
Below 14	Very cold
14 to 18	Cold
18 to 22	Cool
22 to 26	Slightly cool
26 to 30	Neutral
30 to 34	Slightly warm
34 to 38	Warm
38 to 42	Hot
Above 42	Very hot

Information Architecture and Dissemination Design

Computed information was organised into three separated nodes, shown in Figure 1.

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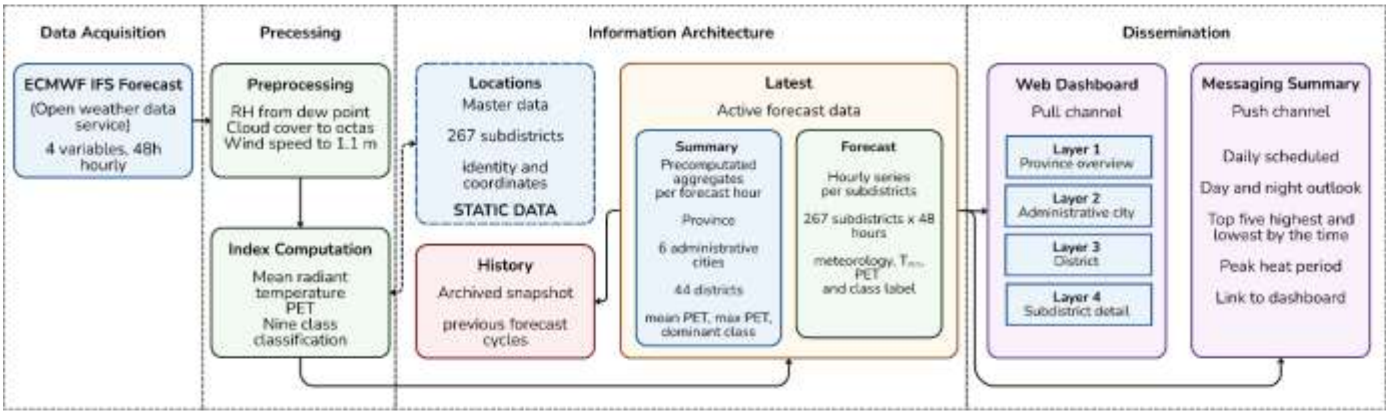

Figure 1. Three-node information architecture and multichannel dissemination flow

The first node holds static master data, transferred once rather than at each refresh. The second holds the active forecast as the single reference for both channels, and the third archived snapshots outside the active read path, so history does not affect normal retrieval. Both dynamic nodes were hosted on a realtime database service, as in comparable Indonesian applications [16], [17].

Within the active node, the summary branch holds aggregates precomputed per forecast hour for the province, cities, and districts, each carrying mean PET, maximum PET, and the dominant class, while the forecast branch holds the hourly series per subdistrict with its meteorological inputs, T_{mrt}, PET, and class label. Aggregation thus occurs on the provider side, so the four exploration layers of the responsive web application are served without reading the subdistrict dataset.

The second channel delivers a scheduled summary through a messaging platform already used for weather information in Indonesia [18], reporting the forecast date, a day and night outlook, the five highest and five lowest subdistricts by PET, the peak heat period, and a dashboard link.

Evaluation Method

Functional testing followed a black box approach, since the object of evaluation is the information reaching the user rather than the internal correctness of the code. Exhaustive traversal of 267 subdistricts across 48 forecast hours is infeasible, so equivalence partitioning reduced that space to twelve scenarios spanning the four exploration layers and the messaging channel [19]. Each scenario recorded an expected outcome against the observed result, and testing was carried out by the authors on the deployed system.

Usability was assessed with the System Usability Scale (SUS) in its validated Indonesian adaptation [20]. Twelve respondents aged 21 to 25 took part, several of whom had prior familiarity with meteorology or information technology. Each completed four exploration tasks, one per exploration layer, covering the provincial average at a given hour, the warmest administrative city at that hour, navigation to a specified subdistrict, and its warmest hour from the diurnal curve. Participation was voluntary and responses were recorded anonymously. The sample follows Tullis and Stetson [21], who found twelve to fourteen participants sufficient for stable SUS conclusions, and the assessment is formative rather than a benchmark. Scores were computed in the standard manner [22], an approach also applied to official public service websites [23].

4. Results and Discussion

Implemented Information Architecture

Table 3 summarizes the structure and measured size of each node for a 48-hour forecast cycle.

Table 3. Structure and measured size of the implemented information nodes

Node	Records	Attributes per record	Payload	Role in delivery
locations	267	6	45.8 KB	Master identity and coordinates, static across forecast cycles
latest / summary	2,448	4 to 6	284.1 KB	Precomputed aggregates for the province, 6 cities, and 44 districts at each of 48 hours
latest / forecast	12,816	9	3,053.2 KB	Hourly series for 267 subdistricts across 48 hours
history	One snapshot per cycle, retained about one month	Mirrors the active node	Grows with retention	Archive held outside the active read path

Within the 3,337.3 KB active node, the aggregate branch occupies only 8.5 percent of the total size while supporting all administrative levels for every forecast hour. Rendering the provincial, city, and district views requires only 5.90 KB, compared with 3,053.2 KB if aggregated directly from subdistrict records, a 518-fold reduction in transferred data. The comparison holds because the forecast branch is keyed by location, so retrieving one hour across all subdistricts still requires reading every hourly series in full. Accessing one subdistrict adds only 11.41 KB, resulting in a complete drill-down path of approximately 17 KB.

The aggregate branch is therefore not a cache but a separate representation of the same information at a coarser grain, since it holds means, maxima, and dominant classes that appear nowhere in the subdistrict series, allowing a coarse question to be answered without touching fine data.

Multichannel Delivery Layer

The delivery layer implements the hierarchy as four exploration layers, shown in Figures 2 and 3.

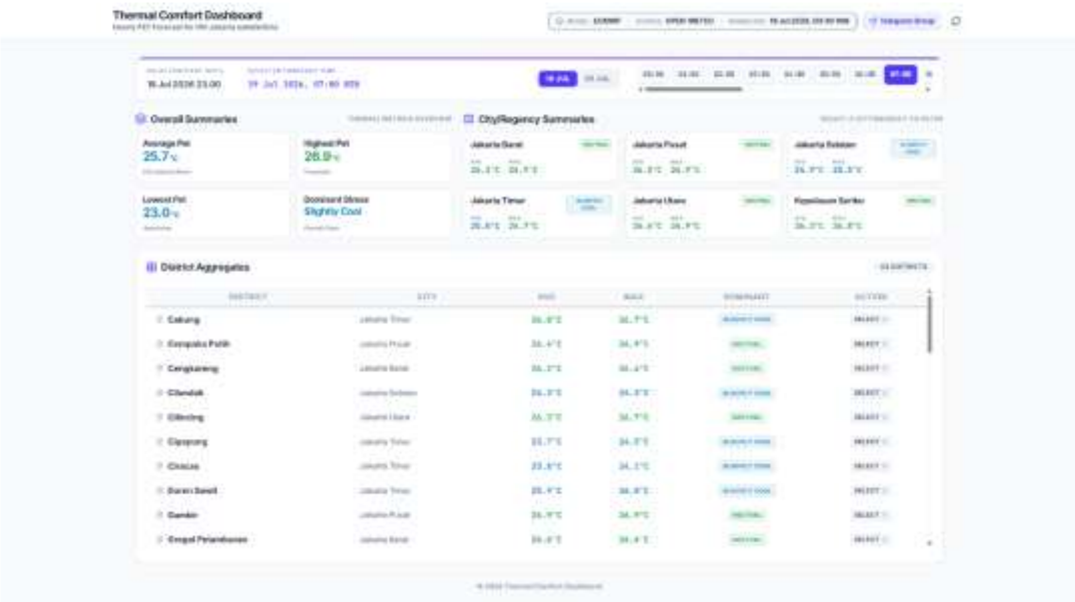

Figure 2. Dashboard exploration across province, city, and district levels

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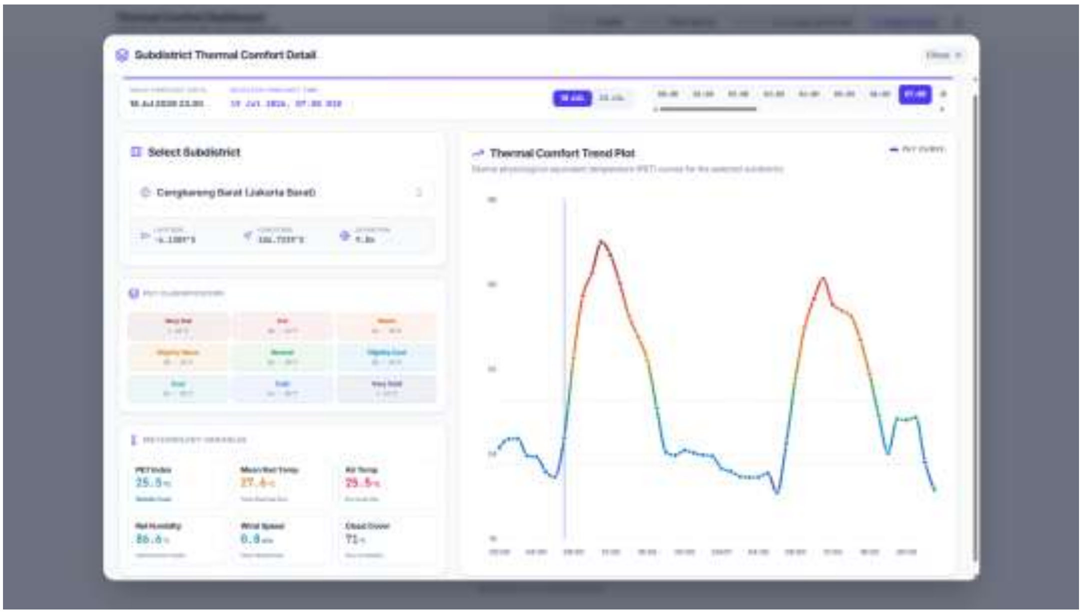

Figure 3. Subdistrict detail layer with meteorological variables and diurnal PET curve

The design progressively narrows the search space instead of relying on keyword retrieval, so users searching for a subdistrict never face all 267 options. The first layer answers the broadest question without input. As shown in Figure 2, the state on 19 July 2026 at 07.00 reports a provincial mean of 25.7 °C with a dominant slightly cool class. The second layer lists six administrative cities, the third their districts, and the fourth the selected district's subdistricts, averaging about six. Users therefore scan at most 44 districts, or ten after choosing a city. Name search remains available for users who already know their subdistrict. Across all layers, every value appears with its class label. Only the fourth layer, shown in Figure 3, breaks the index into T_{mrt}, air temperature, RH, wind speed, and cloud cover. Keeping this breakdown until the final layer preserves categorical navigation, allowing users unfamiliar with the PET scale to rely on the class while still accessing the underlying variables.

Figure 4. Scheduled daily summary delivered through the messaging channel

As shown in Figure 4, the messaging channel inverts the direction of delivery. Carrying ten of 267 subdistricts, it is not a compressed dashboard but a different informational product, intended to establish that a condition exists rather than to support investigation of it, with the closing link transferring an interested reader into the exploratory channel. The two channels therefore address different states of the same user, one who already has a question and one who does not yet know there is something to ask.

Evaluation Results

Table 4 reports the functional testing. All twelve scenarios produced the expected outcome.

Table 4. Functional testing scenarios and observed results

No	Test scenario	Expected outcome	Observed result	Status
1	Load the dashboard at the initial forecast hour	Overview, city, and district levels are rendered	Three aggregate levels rendered from a 5.90 KB payload	Pass
2	Select a different hour within the same day	All aggregate levels update to the selected hour	Values updated across all levels for the selected hour	Pass
3	Select the following forecast day	Available hours change to the selected day	Hour set switched within the 48-hour horizon	Pass
4	Select one administrative city card	Displayed aggregates narrow to the selected city	District list narrowed to the districts of that city	Pass
5	Display the district aggregate table	All districts are listed with their aggregates	44 districts listed with mean PET, maximum PET, and dominant class	Pass
6	Open the detail panel from a district row	Detail panel opens for the selected district	Detail panel opened at a subdistrict of that district	Pass
7	Search and select a specific subdistrict	Selector lists the subdistricts available for selection	Selector listed the subdistricts of the selected district, with all 267 reachable	Pass
8	Display the variables of the selected subdistrict	Meteorological variables and indices are shown	Six variables displayed, including PET and mean radiant temperature	Pass
9	Display the PET trend of the selected subdistrict	Hourly curve is rendered across the horizon	48 hourly points rendered from an 11.41 KB single subdistrict payload	Pass
10	Compare displayed values against the classification legend	Colour and label match the class range	Colour and label matched the nine-class ranges at every checked point	Pass
11	Trigger a manual data reload	The latest available forecast is retrieved	Generation timestamp and all displayed values updated to the newest forecast	Pass
12	Receive the scheduled summary message	Message contains the specified components	Message dispatched once a new forecast was generated, containing all specified components	Pass

The usability assessment produced a mean SUS score of 85.2 with a standard deviation of 4.5 across twelve respondents, ranging from 77.5 to 92.5. Every respondent returned at least 70, placing all twelve responses within the acceptable range, and the mean sits well above the average of roughly 70 reported across a large body of SUS studies [22].

Item level results are more diagnostic than the aggregate. The most favourable response concerned prior learning, where a mean raw score of 1.08 on the reversed item indicates that respondents needed to learn almost nothing before using the interface, while the least favourable, though still positive, concerned confidence during use at 3.08 of a possible 4 points.

Discussion

The architecture and its channel pairing extend criteria established in the dashboard literature into a domain where they have not been applied. Ivanković et al. [11] treat high spatial resolution and meaningful disaggregation as constituent features of an actionable dashboard, yet presenting 267 subdistricts at once would satisfy both criteria formally while defeating them in practice, since the reader would face an undifferentiated list. Retaining subdistrict resolution in the data while never exposing more than 44 options at a single decision point resolves that tension, so the contribution lies not in achieving high resolution, which the forecast data supplies, but in making it navigable. Navigability still assumes a reader who arrives, and Stahlman et al. [10] found that most reviewed dashboards reported neither a usability assessment nor any account of how users were expected to discover them. Pairing the dashboard with a scheduled push channel therefore treats discovery as a design problem rather than a downstream concern.

Precomputation carries an explicit trade-off, raising stored volume by 9.3 percent and obliging aggregates to be regenerated whenever the underlying series changes, while removing aggregation logic from the client and cutting what the aggregate layers must read by more than two orders of magnitude. The exchange favours precomputation because the data are written once per cycle and read many times, whereas the opposite ratio would favour aggregation at the point of use.

The usability results support the navigational design and qualify the interpretive one, since ease of navigation and confidence in interpretation are not the same property. A reader can reach the value for their subdistrict without difficulty and still be uncertain what it means, particularly when the index is unfamiliar and its scale differs from the air temperature reading encountered elsewhere. The nine-class labels reduce that distance without closing it, placing interpretive support in the domain of information design rather than computation.

Several limitations apply. The 48-hour horizon from a single model describes a short outlook rather than a general characterisation of the thermal environment. Model resolution is coarser than the administrative resolution of presentation, and values are computed for a single standard reference subject, so subdistrict figures represent area conditions for a normative adult rather than independently resolved measurements across the range of ages, clothing, and activity levels in the intended audience. The usability assessment is formative and its respondents were young adults, some already familiar with meteorology or information technology, so it supports conclusions about the presentation as designed but neither comparison with other systems nor generalisation to the older residents most exposed to heat risk. The system has not been evaluated in longitudinal use, and computed values have not been validated against field measurements.

5. Conclusion

This study designed and evaluated a multichannel information architecture for PET-based thermal comfort information covering 267 subdistricts in DKI Jakarta. The architecture separates master data, active forecast, and archived snapshots, placing precomputed aggregates alongside the full hourly series so that all four exploration layers are served from a single reference, and dissemination pairs an exploratory dashboard with a scheduled messaging summary.

The design answers the research question by making high resolution information navigable rather than merely available. Progressive narrowing keeps the choice set small at every step, precomputation shifts aggregation away from the client, and the push channel addresses discovery. Functional testing confirmed the delivery paths, and the usability assessment placed the presentation well above the reported average, with ease of initial use as its strongest aspect and confidence in interpretation as its weakest.

Limitations concern the forecast horizon and model, the difference between model and presentation resolution, the formative scale of the usability assessment, and the absence of longitudinal and field validation. Further work should address interpretive support for non-expert readers, longitudinal observation of channel use, validation against field measurements, and extension to other urban areas.

6. References

[1] S. Siswanto *et al.*, "Spatio-temporal characteristics of urban heat island of Jakarta metropolitan," *Remote Sens. Appl.*, vol. 32, p. 101062, 2023, doi: 10.1016/j.rsase.2023.101062.

[2] F. R. Fajary, H. S. Lee, and T. Kubota, "Comprehensive spatiotemporal evaluation of urban growth, surface urban heat island, and urban thermal conditions on Java island of Indonesia and implications for urban planning," *Heliyon*, vol. 10, no. 13, p. e33708, 2024, doi: 10.1016/j.heliyon.2024.e33708.

[3] R. Ufaira, S. Amir, G. S. Indraprahasta, and A. Nastiti, "Living in a hot city: thermal justice through green open space provision," *Frontiers in Human Dynamics*, vol. 5, p. 1237515, 2023, doi: 10.3389/fhumd.2023.1237515.

[4] S. Manimaran *et al.*, "Widespread heat stress will become the norm in a warming Southeast Asia," *Sci. Rep.*, vol. 15, 2025, doi: 10.1038/s41598-025-28817-6.

[5] S. F. A. P. Macagba and L. L. Delina, "The state and future of extreme heat studies in Southeast Asian megacities: risk, impacts and adaptation strategies in a warming world," *Environ. Res. Commun.*, vol. 6, no. 11, p. 112003, 2024, doi: 10.1088/2515-7620/ad9145.

[6] S. Patle and V. V Ghuge, "Evolution and performance analysis of thermal comfort indices for tropical and subtropical region: a comprehensive literature review," *International Journal of Environmental Science and Technology*, vol. 21, pp. 10217–10258, 2024, doi: 10.1007/s13762-024-05703-8.

[7] W. Jing, Z. Qin, T. Mu, Z. Ge, and Y. Dong, "Evaluating thermal comfort indices for outdoor spaces on a university campus," *Sci. Rep.*, vol. 14, no. 1, p. 21253, 2024, doi: 10.1038/s41598-024-71805-5.

[8] T. P. Lin and A. Matzarakis, "Tourism climate information based on human thermal perception in Taiwan and Eastern China," *Tour. Manag.*, vol. 32, no. 3, pp. 492–500, 2011, doi: 10.1016/j.tourman.2010.03.017.

[9] M. Haiqal, L. H. Sari, H. Husin, A. Akhyar, A. Munir, and K. Bilqis, "The thermal comfort performance in an Indonesian refugee tent: Existing conditions and redesigns," *Energies (Basel).*, vol. 18, no. 5, p. 1249, 2025, doi: 10.3390/en18051249.

[10] G. Stahlman, I. Yanovitzky, and M. Kim, "Design, Application, and Actionability of US Public Health Data Dashboards: Scoping Review," *J. Med. Internet Res.*, vol. 27, no. 1, p. e65283, 2025, doi: 10.2196/65283.

[11] D. Ivanković *et al.*, "Features Constituting Actionable COVID-19 Dashboards: Descriptive Assessment and Expert Appraisal of 158 Public Web-Based COVID-19 Dashboards," *J. Med. Internet Res.*, vol. 23, no. 2, p. e25682, 2021, doi: 10.2196/25682.

[12] P. Zippenfenig, "Open-Meteo.com Weather API," 2023, *Zenodo*. doi: 10.5281/zenodo.8112599.

[13] O. A. Alduchov and R. E. Eskridge, "Improved Magnus form approximation of saturation vapor pressure," *Journal of Applied Meteorology*, vol. 35, no. 4, pp. 601–609, 1996, doi: 10.1175/1520-0450(1996)035<0601:IMFAOS>2.0.CO;2.

[14] M. G. Lawrence, "The relationship between relative humidity and the dewpoint temperature in moist air: A simple conversion and applications," *Bull. Am. Meteorol. Soc.*, vol. 86, no. 2, pp. 225–233, 2005, doi: 10.1175/BAMS-86-2-225.

[15] Y. C. Chen, "Thermal Indices for Human Biometeorology Based on Python," *Sci. Rep.*, vol. 13, no. 1, Dec. 2023, doi: 10.1038/s41598-023-47388-y.

[16] I. F. Maulana, "Penerapan Firebase Realtime Database pada Aplikasi E-Tilang Smartphone berbasis Mobile Android," *Jurnal RESTI (Rekayasa Sistem dan Teknologi Informasi)*, vol. 4, no. 5, pp. 854–863, 2020, doi: 10.29207/resti.v4i5.2232.

[17] K. N. M. Ngafidin, A. Arista, and R. N. S. Amriza, "Implementasi Firebase Realtime Database pada Aplikasi FeedbackMe sebagai Penghubung Guru dan Orang Tua," *Jurnal RESTI (Rekayasa Sistem dan Teknologi Informasi)*, vol. 5, no. 2, pp. 327–334, 2021, doi: 10.29207/resti.v5i2.2909.

[18] D. N. Bestari and A. Wibowo, "An IoT-Based Real-Time Weather Monitoring System Using Telegram Bot and Thingsboard Platform," *International Journal of Interactive Mobile Technologies*, vol. 17, no. 6, pp. 4–19, 2023, doi: 10.3991/ijim.v17i06.34129.

[19] M. Zidan, S. Nur'aini, N. C. H. Wibowo, and M. A. Ulinuha, "Black Box Testing pada Aplikasi Single Sign On (SSO) di Diskominfostandi Menggunakan Teknik Equivalence Partitions," *Walisongo Journal of Information Technology*, vol. 4, no. 2, pp. 127–137, 2022, doi: 10.21580/wjit.2022.4.2.12135.

[20] Z. Sharfina and H. B. Santoso, "An Indonesian adaptation of the System Usability Scale (SUS)," in *2016 International Conference on Advanced Computer Science and Information Systems (ICACSIS)*, Malang, Indonesia: IEEE, 2016, pp. 145–148. doi: 10.1109/ICACSIS.2016.7872776.

[21] T. S. Tullis and J. N. Stetson, "A Comparison of Questionnaires for Assessing Website Usability," 2004. [Online]. Available: https://api.semanticscholar.org/CorpusID:9670323

[22] A. Bangor, P. T. Kortum, and J. T. Miller, "An empirical evaluation of the System Usability Scale," *Int. J. Hum. Comput. Interact.*, vol. 24, no. 6, pp. 574–594, 2008, doi: 10.1080/10447310802205776.

[23] S. N. Fitrianingrum, A. W. A. Wibowo, and B. D. Rahmawati, "System Usability Scale (SUS) as an analysis method for official website," *Telematika*, vol. 21, no. 2, pp. 173–180, 2024, doi: 10.31515/telematika.v21i2.12918.