Feeling the Heat: A Simple Discomfort Score Approach to Mapping Thermal Stress Among Selected Cities in Negros Oriental

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Abstract

This study examined urban heat discomfort in three cities of Negros Oriental, namely, Canlaon City, Tanjay City, and Dumaguete City using a simplified indicator called the Heat Discomfort Score (HDS). The HDS was computed from monthly average temperature and relative humidity data for 2024 to 2025 obtained from reliable meteorological sources. The computational formula used was: HDS = (T × RH) / 100, where T represents average monthly temperature (°C) and RH represents average monthly relative humidity (%). Results show that all three cities experienced varying levels of heat discomfort across the two-year period, with Canlaon City generally exhibiting the highest HDS values, followed by Tanjay City and Dumaguete City. HDS tended to be higher during warmer and more humid months, particularly from May to December in both years. This indicates that climatic conditions, with the combination of temperature and humidity—have a noticeable influence on perceived heat discomfort in these tropical urban areas. The findings suggest that the Heat Discomfort Score is a practical and accessible tool for measuring and comparing heat stress in different urban environments. Its simplicity makes it suitable for community awareness, public health preparedness, and local planning efforts in regions vulnerable to heat stress due to temperature and humidity interactions.

Keywords: Heat Discomfort Score, Urban Heat, Temperature, Humidity, Canlaon City, Tanjay City, Dumaguete City, Climate Stress

Introduction

Mathematics has an important role in making sense of and solving the problem of the environment, offering methods that enable the quantification, analysis, and interpretation of complex processes of nature. Using mathematical calculations, the state of the environment, including variations of the climate, interactions of the atmosphere, as well as heat stress, among other factors, can be represented by important indicators. As global warming persists, mathematical models or indices have become essential elements in analyzing how warming, along with increasing humidity, influences human comfort when it comes to these effects associated with increasing warming in tropical areas (Blazejczyk et al., 2018; IPCC, 2021).

At the global scale, various research efforts have indicated that heat discomfort and health problems are primarily driven by the combined effect of air temperatures and relative humidities, rather than temperatures alone. High values of relative humidity affect the body's perspiration system by restricting it from cooling down the body by evaporation, making it feel like higher temperatures and leading to various heat-associated illness symptoms (Mora et al., 2019; Parsons, 2020). To more accurately represent such combined effects, myriad heat stress indices including the Heat Index and Wet Bulb Globe Temperature (WBGT) indices are employed. However, most of these indices are complex with numerous variables, resulting in difficulties with their accessibility and applications, especially in developing nations.

In the Philippines, the problem of heated conditions is persistent because of the country's tropical climate, the continuously high relative humidity, and the rapid growth of urbanization. In the country, the monitoring systems on heated conditions established by the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) regularly record a high heat index and often alert the public to safeguard public health (PAGASA, 2023).

In the Philippines, studies have shown that the effects of urbanization, the heat island effect, and the continuously high humidity can greatly aggravate the experience of heated conditions among the public even without the occurrence of a heatwave (Bilang et al., 2019; Manalo, 2022). However, the results obtained are often through the use of complex climate models or heat indicators that are difficult to implement at the school and LGU levels.

In the province of Negros Oriental, cities such as Canlaon City, Tanjay City, and Dumaguete City have been observed to have varying degrees of heat discomfort based on their altitude, whether inland or coastal, and characteristics of the place as Urban. In Canlaon City, it was observed that despite the relatively high altitude, humidity is high; in Tanjay City, it reflects the inland climate characteristics; while in Dumaguete City, as it is mostly coastal and an urban area, moisture from neighboring bodies of water impacts the place. Though there are limited studies locally which focused on the comparison of heat discomfort among the cities using simple mathematical computations based solely on climatic properties.
This case study emphasizes the need to integrate math to create a useful solution to transform readily available temperature and relative humidity information into an actionable format of heat perception. The simplified Heat Discomfort Score (HDS), calculated by the formula HDS = (T × RH) / 100, gives area residents an accurate means of estimating how uncomfortable the heat may be without requiring sophisticated equipment or expert analysis. The HDS enables residents of any area to get an idea of how potentially undesirable heat conditions exist.

This study determines the heat discomfort of Canlaon City, Tanjay City, and Dumaguete City by computing and comparing the monthly Heat Discomfort Scores from 2024 to 2025. By identifying the periods of higher and lower discomfort, the study investigates variations that may have existed among the three cities and shows how mathematics could be used to interpret real-world conditions on the environment. The results add to raising public awareness, helping health preparedness, and informing local planning; they stress how important mathematical applications are when it comes to addressing environmental challenges linked with climate change and urbanization.

Literature Review

Thermal stress is a growing concern in tropical and near coastal areas where high ambient temperatures are often accompanied by high relative humidity. Modern research on thermal comfort argues that heat perception by the human body is a function of the interaction between ambient air temperatures and humidity because the body can only deal with heat loss by evaporating sweat in a low-humidity environment; otherwise, heat comfort and heat distress are enhanced by the simultaneous effect of the two conditions, regardless of the ambient air temperatures (Blazejczyk et al., 2018; Parsons, 2020).

In reaction to these physiological interactions, new heat indices have been developed that better determine human perceptions. Heat indices that incorporate air temperatures and humidity measurements have been instrumental in estimating the potential heat and the related health risks. Heat indices that have been useful in communicating heat perceptions, being relatively simple and practical, include Heat Index and Apparent Temperature. The Heat indices that have been set for occupational and research work, being relatively complex, include the Wet-Bulb Globe Temperature (WBGT) (Parsons, 2020; Mora et al., 2019).

In the Philippines, the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) promotes this theoretical model through its Heat Index Monitoring and Forecasting System and iHeatMap information platform. These systems provide air temperature and relative humidity data to identify and forecast the level of heat risk and provide warnings to the public. The continually improved systems of PAGASA demonstrate the increase in awareness that humidity has a big effect on how much actual heat is felt, especially because it is a tropical country.

Empirical research carried out in the Philippines has also validated the need for joint estimation of temperature and humidity. Bilang et al. (2022) simulated an extreme heat event in Metro Manila using the Weather Research and Forecasting (WRF) model for the simulation of an urban canopy. According to the article, high humidity has been observed to exacerbate perceived levels of high temperatures. Urban morphology has also been observed to influence local temperatures and humidity levels.

National-scale studies have recently highlighted the importance of the climate exposure and vulnerability interaction. Marquez and Narisma (2020) conducted a heat health risk assessment of Philippine cities using remotely sensed data and social-ecological indicators. Their findings showed that cities with higher temperatures, persistent humidity, and limited adaptive capacity experienced greater heat-related risks, underscoring the need for accessible heat stress indicators that can be applied at the local level.

In recent climate-related studies of urban areas, it was shown that the intensity of thermal stress and heat discomfort continues to observe an increase on the Philippine urban scene. Llorin et al. (2024) established the fact that the intensity of the urban heat island phenomenon and the warmer surface and near-surface air temperatures over Metro Manila have intensified because of the changes taking place in the land use and atmospheric parameters.

Evidence from public health and climate risk studies also supports the relevance of the proposed simplified heat metrics. Mora et al. (2019) illustrated that joint heat and humidity events have a significant association with heightened health-related risk around the globe, mainly over tropical and near-coastal areas. Regional projections presented in the study of Raymond et al. (2020) indicate that humid heat extremes will occur more frequently with an expected change in climate, thus adding to the importance of more convenient thermal discomfort estimation methods.

In general, the current literature has proven the existence of a consistency between the measurement of thermal discomfort and the use of indices that quantify the variables of air temperature and relative humidity. Although Heat Index and WBGT are highly scientific in their measurement process, their abstract nature can create limitations when it comes to local planning. This creates an opportunity for the application and use of a Heat Discomfort Score (HDS) that has been documented in recent literature and can be applied in the mapping of thermal discomfort in mid-sized cities like Canlaon, Tanjay, and Dumaguete in the Philippines.

Methodology

Computational mathematics plays a crucial role in environmental and climate-related studies, as it allows researchers to process large sets of numerical data, identify patterns, and transform raw measurements into meaningful indicators. In studies involving climatic variables such as temperature and relative humidity, computational methods are essential because these variables interact in complex ways that cannot be accurately interpreted through simple observation alone. By applying mathematical models and computations, researchers can quantify environmental phenomena and present them in a form that supports comparison, analysis, and decision-making (Parsons, 2020; Mora et al., 2019).

In this study, the computational mathematics approach was employed to objectively assess and compare urban heat discomfort across selected cities in Negros Oriental. The use of computational methods is particularly crucial because perceived heat discomfort is not solely dependent on-air temperature but is significantly influenced by relative humidity, especially in tropical regions like the Philippines. Integrating these variables through a mathematical formula enables the researchers to convert climatological data into a simplified yet reliable indicator of heat discomfort (Blazejczyk et al., 2018).

This study employed a quantitative–descriptive–computational research design to analyze and compare levels of urban heat discomfort in selected cities of Negros Oriental, namely Canlaon City, Tanjay City, and Dumaguete City, for the period 2024 to 2025. Computational mathematics was utilized as the primary approach to process climatic data and transform temperature and relative humidity measurements into a simplified indicator of perceived heat discomfort.

Secondary climatological data consisting of monthly average air temperature (°C) and monthly average relative humidity (%) were collected for each month from January to December of both years for all three cities. These cities were selected to represent differing geographical settings: Canlaon City as a highland area, Tanjay City as an inland urban area, and Dumaguete City as a coastal city.

For Canlaon City in 2024, monthly average temperatures ranged from 28 °C to 31 °C, while relative humidity values varied between 78% and 87%. Higher temperatures were recorded from April to June, with the warmest month occurring in May, while the highest humidity values were observed during the latter months of the year. Using these data, monthly Heat Discomfort Scores (HDS) were computed, with consistently elevated values observed from May to December. For Canlaon City in 2025, temperatures ranged from 27 °C to 30 °C, with relative humidity values between 78% and 87%. The lowest temperature was recorded in September, while higher humidity levels were observed from August to November. Monthly HDS values remained consistently high across the year, providing a detailed temporal profile of heat discomfort for the highland city.

For Tanjay City in 2024, monthly average temperatures ranged from 28 °C to 30 °C, while relative humidity values varied between 70% and 82%. Lower temperature and humidity conditions were observed during the early months of the year, particularly from January to April, while higher humidity values were recorded from June to December. Monthly HDS values were computed for each month, reflecting moderate heat discomfort levels that increased during warmer and more humid periods. For Tanjay City in 2025, temperatures ranged from 28 °C to 30 °C, with relative humidity values between 74% and 82%. The lowest relative humidity was recorded in April, while higher humidity levels persisted from June to November. The computed HDS values allowed for month-by-month and year-to-year comparison of heat discomfort trends in the inland urban setting.

For Dumaguete City in 2024, monthly average temperatures ranged from 28 °C to 30 °C, while relative humidity values varied between 70% and 82%. Monthly HDS values ranged from 20.59 in March to 22.96 in December, with higher values generally observed from June onward, corresponding to increased humidity levels despite relatively stable temperatures. For Dumaguete City in 2025, temperatures ranged from 28 °C to 30 °C, with relative humidity values between 74% and 82%. The resulting HDS values ranged from 21.84 in March to 22.96 in November, with consistently elevated scores from June to November. These computations provided a detailed temporal representation of heat discomfort for the coastal city across two consecutive years.

According to national and international climate assessments, increasing air temperatures combined with high relative humidity have intensified heat-related discomfort and health risks in tropical countries such as the Philippines (Parsons, 2020; Mora et al., 2019). These conditions are particularly evident in urban areas, where local geography and urbanization further influence thermal stress. To address this concern, the present study adopts a localized and city-level analytical approach to identify variations in heat discomfort across different urban environments in Negros Oriental. To quantify heat discomfort, the study applied the Heat Discomfort Score (HDS), a simplified mathematical model expressed as:

$$HDS = (T \times RH) / 100$$

Where:
HDS = Heat Discomfort Score
T = Average Monthly Temperature
RH = Average Monthly Relative Humidity

Conceptual Framework

The researchers aim to measure and differentiate the degree of heat discomfort within Canlaon City, Tanjay City, and Dumaguete City from the year 2024 to 2025 through the application of a simplified mathematical model called the Heat Discomfort Score, or HDS. As discussed, this approach helps the researchers understand the way and the degree to which the changes of temperature and relative humidity affect the heat discomfort of a place. The study systematically unfolds through three main parts, including A. Input, B. Process, and C. Output.

Results

The results derived from the formulated Heat Discomfort Score (HDS) equation is summarized in the tables below. These tables present the monthly average temperature and relative humidity values used in the computation, along with the corresponding HDS values for Canlaon City, Tanjay City, and Dumaguete City from 2024 to 2025. The tabulated results illustrate the variation in heat discomfort across cities and months and provide a basis for analyzing the relationship between temperature, relative humidity, and perceived heat discomfort.

The Process begins with the collection of monthly temperature and relative humidity data from reliable meteorological sources. The gathered data are then organized according to city, month, and year. Using the mathematical formula $HDS = (T \times RH) / 100$, the researchers compute the Heat Discomfort Score for each city and time period. The computed HDS values are analyzed and compared across months and between cities to identify patterns, trends, and variations in heat discomfort.

The Output of the study includes the computed monthly and yearly HDS values for Canlaon City, Tanjay City, and Dumaguete City, the identification of months with the highest and lowest heat discomfort, and a comparative heat discomfort profile among the three cities. These results provide a simplified yet practical assessment of urban heat discomfort and demonstrate how computational mathematics can be effectively used to support public awareness, health preparedness, and local government planning in response to increasing heat stress.

Table 1. Comparison data of Canlaon City, Tanjay City, and Dumaguete City (2024)

MONTH	TEMPERATURE (°C)			RELATIVE HUMIDITY (%)			HDS VALUE		
	Canlaon City	Tanjay City	Dumaguete City	Canlaon City	Tanjay City	Dumaguete City	Canlaon City	Tanjay City	Dumaguete City
JAN	28°C	28°C	28°C	82%	76%	76%	22.96	21.28	21.28
FEB	28°C	28°C	28°C	83%	76%	76%	23.24	21.28	21.28
MAR	29°C	29°C	29°C	79%	71%	71%	22.12	20.59	20.59
APR	30°C	30°C	30°C	78%	70%	70%	23.4	21	21
MAY	31°C	30°C	30°C	78%	70%	70%	24.28	21	21
JUNE	30°C	29°C	29°C	82%	77%	77%	24.6	22.33	22.33
JULY	28°C	28°C	28°C	85%	80%	80%	23.8	22.4	22.4
AUG	29°C	28°C	28°C	84%	80%	80%	24.36	22.4	22.4
SEP	28°C	29°C	29°C	84%	78%	78%	23.52	22.62	22.62
OCT	28°C	29°C	29°C	84%	78%	78%	23.52	22.62	22.62
NOV	29°C	29°C	29°C	84%	78%	78%	24.36	22.62	22.62
DEC	28°C	28°C	28°C	87%	82%	82%	24.36	22.96	22.96

Table 2. Comparison data of Canlaon City, Tanjay City, Dumaguete City (2025)

MONTH	TEMPERATURE (°C)			RELATIVE HUMIDITY (%)			HDS VALUE		
	Canlaon City	Tanjay City	Dumaguete City	Canlaon City	Tanjay City	Dumaguete City	Canlaon City	Tanjay City	Dumaguete City
JAN	28°C	28°C	28°C	85%	80%	80%	23.8	22.4	22.4
FEB	28°C	28°C	28°C	83%	79%	79%	23.24	22.12	22.12
MAR	28°C	28°C	28°C	83%	78%	78%	23.24	21.84	21.84
APR	30°C	30°C	30°C	78%	74%	74%	23.4	22.2	22.2
MAY	29°C	29°C	29°C	81%	77%	77%	23.49	22.33	22.33
JUNE	29°C	28°C	28°C	81%	81%	81%	23.49	22.68	22.68
JULY	29°C	29°C	29°C	80%	76%	76%	23.2	22.04	22.04
AUG	28°C	28°C	28°C	84%	79%	79%	23.52	22.12	22.12
SEP	27°C	28°C	28°C	87%	81%	81%	23.49	22.68	22.68
OCT	28°C	28°C	28°C	85%	81%	81%	23.8	22.68	22.68
NOV	28°C	28°C	28°C	87%	82%	82%	24.36	22.96	22.96

Discussion

This study presented the Heat Discomfort Score (HDS) of Canlaon City, Tanjay City, and Dumaguete City using monthly average temperature and relative humidity data from 2024 to 2025. Based on the data collected, the results showed that heat discomfort varies between cities and across months due to the interaction of temperature and humidity, as well as differences in geographic and urban characteristics. Previous studies indicate that areas with higher proportions of built-up and solid surfaces tend to experience greater heat stress because of increased heat absorption and reduced vegetation cover, while greener areas generally exhibit lower thermal discomfort (Ahmed et al., 2021; Yang et al., 2022). Moreover, geographic factors such as topography and local airflow patterns can further influence how heat is distributed and perceived in urban environments (Zhang et al., 2024). These factors likely explain the observed spatial and temporal variations in heat discomfort among the three cities.

Results show that Canlaon City consistently posted the highest HDS values among the three cities for both years. Peak discomfort levels were attained during warmer and more humid months or from May to August. Even though Canlaon City has relatively higher elevations, it still had high heat discomfort due to consistently high relative humidity, implying that humidity is a major contributing factor in increasing perceived heat stress. Physiologically, high humidity reduces the body's ability to shed heat through sweat evaporation, the primary cooling mechanism at elevated temperatures, because moist air slows the evaporation of sweat from the skin, leading to greater internal heat retention and higher perceived heat stress compared to drier conditions (Sawka et al., 2011). In hothumid environments, studies have shown that an increase in relative humidity at elevated temperatures significantly raises thermal discomfort and the sensation of "feeling hotter," even when the actual air temperature remains the same (Human responses to high humidity, 2016). Thus, the consistently high humidity in Canlaon City likely intensified the perceived heat stress despite its higher elevation. This supports the conceptual framework of the study, which emphasizes the combined effect of temperature and humidity on thermal discomfort.

In contrast, Tanjay City has shown a moderate and relatively stable HDS during the study period. The discomfort levels were lower during the early months of the year, with slight increases during the rainy months. The relatively small variation in HDS for Tanjay City indicates that it experiences less extreme heat discomfort. This difference may be related to its inland location and more balanced climatic conditions, which provide more stable daily temperatures and less influence from coastal humidity, highlighting how geographic and environmental factors can modulate heat stress across different cities (Peng & Watanabe, 2025).

Dumaguete City also exhibited a moderate level of heat discomfort, and its graphs were similar to those observed in Tanjay City. Higher HDS was experienced when the relative humidity during a particular month increased, especially during the latter part of the year. Although Dumaguete City is a coastal and urbanized area, its heat discomfort could be increased by the moisture from nearby bodies of water and the urban heat retention caused by built-up surfaces. Studies show that coastal cities and highly urbanized areas often experience higher thermal discomfort due to combined raised perceived temperatures (Oke, 1982; Santamouris, 2015).

Comparison among the three cities reveals that geographic location and climate also contribute significantly to heat discomfort. Even though Canlaon City had higher HDS, Tanjay City and Dumaguete City had similar levels of discomfort due to medium care. For all cities, higher levels of HDS occur in warmer and hotter months.

The results imply that HDS is a feasible and easily accessible indicator for estimating urban heat discomfort. This may lead to increasing the awareness of the public and supporting local government efforts in heat preparedness and urban planning. Limitations of this study are presented, dealing with secondary data and involving a simplified formula that did not account for the effect of other climatic factors such as wind speed and solar radiation.
In sum, the study confirms that temperature and relative humidity jointly influence heat discomfort. More importantly, local geographic conditions continue to play a key role in shaping heat stress experiences in the urban area of Negros Oriental.

Conclusion

In conclusion, the Heat Discomfort Score (HDS) was shown to be a useful and accurate mathematical model to measure the impact of hot discomfort on Canlaon City, Tanjay City, and Dumaguete City through the average temperature and relative humidity from 2024 to 2025. The results obtained clearly indicate that hot discomfort is affected by the interaction of temperature and relative humidity. Hot discomfort was shown to be highest during the hotter and more humid months of the year.

The data showed that Canlaon City generally had the highest level of heat discomfort, contributed by high relative humidity, although temperatures are relatively moderate. Tanjay City, followed by Dumaguete City, also had moderate heat discomfort, particularly prevailing in those months that had higher humidity. Notably, heat discomfort can occur in either inland, coastal, or highland areas, although with varying degrees, and these three major cities are no exception, based on their geographical characteristics. That heat discomfort can occur in these areas, regardless of their geography, is a significant point that has been confirmed by this study.

The simplicity of the Heat Discomfort Score allows it to serve as an effective tool for translating climatic data into information meaningful enough to be easily understood by the community, schools, and local government units. By integrating HDS into local climate monitoring, health advisories, and urban planning efforts, decision-makers could more clearly identify periods of high heat discomfort and thereby adopt appropriate measures in a timely manner. Such measures may include adjusting work and school schedules, enhancing public advisories concerning heat, and emphasizing mitigation strategies during months that record high HDS values.

The results of this research indicate that providing heat mitigation measures through local development plans, increasing vegetation cover, improving urban ventilation, and promoting infrastructure resilient to heat should be implemented in areas identified by the discomfort level. Public health and education sectors can also take advantage of HDS as an awareness tool for informing residents on the risks associated with heat and appropriate protective actions. Though simple, the mathematical model, as used in this HDS, forms a basis to capture in a most sensitive way the patterns of heat discomfort and hence deserves a place in the community-friendly approaches to heat stress, now spreading due to climate change and urbanization.

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