Analysis of Community Comfort in the Semarang Area Based on Temperature Distribution Values Using the Temperature Humidity Index

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Abstract. The Semarang Area is the center of socio-economic activity, and manifold people come to improve their living standards. The increasing population growth in Semarang Area due to the rate of urbanization initiates the conversion of vegetation land into built-up land, which has implications for decreasing comfort. This study aimed to analyze community comfort based on the distribution of temperature and the Temperature Humidity Index (THI) in 1999, 2009, and 2019, analyze trends in community comfort based on the level of THI area and analyze the regression and correlation between temperature values and THI. Data processing applied Landsat 5 TM satellite imagery (1999, 2009) and Landsat 8 OLI satellite imagery (2019), google earth engine was utilized to obtain a temperature value. The quantitative data analysis method employed stratified random sampling. The data processing results obtained the highest temperature distribution (>31 °C) in the activity center area, while the temperature < 24 °C–29 °C in vegetated areas in Semarang Regency. Semarang City is recognized for its extremely high THI value (<27 °C (uncomfortable category)). In 1999, the area of THI of class 3 was 20219.8 ha, it increased to 28616.3 ha in 2009, and the largest area was in 2019 with 65481.7 ha. The THI value represents a high value, meaning that the area has a low comfort level, causing less comfortable for people to live in and vice-versa. The simple linear regression correlation test presented that the significant data were normally distributed and the graphs were positively related.

Keywords: Community Comfort · Temperature Humidity Index · Semarang Area

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1 Introduction

An increasing population is a phenomenon that frequently occurs and has a major impact on an area. It relates to the population function, an important parameter in determining a change plan (Pinuji, 2020). Besides being a determinant of change in a region, population growth also frequently generates new problems, such as individual socio-economic problems that can affect the condition of the group. Thus, it greatly influences the adjustment of the surrounding environmental climate. The influence of urbanization is also considered to cause changes in the socio-economic system, which also impacts increasing air temperatures (Hong et al., 2019). It also occurs in the capital city of Central Java Province, Semarang, which is the most populous area. Its function as a central area is the main attraction for most people who must fulfill and improve their life demands with individual and group goals. This phenomenon repeatedly causes effects called "urban sprawl," or the emergence of built-up land caused by low-density and commercial facilities located on land that is still undergoing or not yet undergoing development (Surya et al., 2021). The mentioned areas are Semarang Regency and Salatiga City, slowly having the same characteristics as Semarang City. Semarang Regency as a centralized industrial area for its main cluster area. Meanwhile, Salatiga City indirectly becomes a connector among Semarang Regency, Semarang City, and other regions, including Surakarta City, because national roads traverse its area. The increasing urban community activity habit has resulted in a decrease in green open space, which is the most important function of an area to reduce global and regional carbon dioxide levels due to built-up land (Danardono et al., 2021).

According to Statistics Indonesia (BPS), population mobility in the Semarang area has occurred by 3% annually for the last ten years (2009–2019). In contrast to population mobility, the population growth rate trend tended to slow down to an average of 1.25%. Furthermore, it could have previously reached 1.49% (Statistics Indonesia, 2019). The slower population growth rate had no positive impact on development policies that were harmful to environmental and climate conditions. Community in the equatorial region who prefer to travel by private vehicle may contribute to increasing carbon emissions, which affect temperature. Public activities, including the operation of several modes of transportation, lead to high concentrations of air pollutants due to anthropogenic activities and affect temperature increases (Hadibasyir et al., 2020). Temperature affects the level of air humidity in a particular area. It corresponds to the relations between air temperature and humidity. The higher the temperature, the lower the air humidity, and conversely (Handoko, 2022). Humidity is significantly important in determining the quality of health in an area. Therefore, the air humidity in an area must be balanced with the temperature in the area.

The comfort index study outside the room differs from the comfort study inside the room, especially in the Semarang area, which is currently experiencing development as an urban community activity over time. It is based on the condition that humans can still control the temperature in the room with the presence of an air conditioner. In contrast, the comfort outside temperature only depends on the climate, so it is easier to determine comfort inside than outside. Humans, as members of society, always attempt to obtain comfortable conditions in their living area. Today, numerous people conduct activities indoors and outdoors (Mintarto & Fattahilah, 2019). In addition to human activities affecting the building's comfort to live in, the direction of the building also affects the comfort index. Buildings that back or face the sun will impact air circulation, affecting the temperature inside and outside the room. This height variation is generally found in urban areas, so a comfort level classification is required to improve environmental comfort conditions based on the comfort phenomenon in urban areas such as the Semarang area.

The temperature used in this research is the distribution of temperature values, which are analyzed using the Google Earth Engine (GEE) with an algorithm or programming language to extract the temperature value in the form of brightness temperature. GEE is employed to obtain good image-sharpening results and has been able to display cloud computing with a small percentage (Teluguntla et al., 2018). The relations and influence of temperature variables on the Temperature Humidity Index are obtained by determining samples at several points in the Semarang area. The sample was determined using Arcmap 10.8 software on "tools create random point", based on strata categories in each temperature range. This study aimed to analyze the temperature distribution and community comfort index in the Semarang area in 1999, 2009, and 2019, analyze the trend of community comfort based on the level of THI area, and analyze the regression and correlations that exist between temperature values and the results of the temperature humidity index.

2 Methods

2.1 Study Area and Data

This research was conducted in the Semarang area, which includes Semarang City, Semarang Regency, and Salatiga City. Administratively, Semarang City has 16 sub-districts, Semarang regency has 19 sub-districts, and Salatiga City has four sub-districts, where each sub-district has its function, especially as a center for the socio-economic activities of the population. The Semarang area is an area that has varied topographical conditions. Geographically, Semarang City is located on line 6°50′–7°10′ south latitude and 109° 35′–110° 50′ east longitude with an area of 373.70 km^2. Semarang Regency, geographically located at 110°14′54.75″ to 110°39′3″ east longitude and 7°3′57″ to 7°30′ south latitude, has an area of 950.21 km^2. Salatiga City is located at 007°17′ and 007°17′23″ south latitude and between 110°27′ 56.81″ and 110°32′4.64″ east longitude. The geographical location causes several temperature variations in each region. Total population based on Statistics Central Java Province in each region successively in 1999 in Semarang City (1,429,808 people), Semarang Regency (829,768 people), and Salatiga City (106,361 people); in 2009, the population of Semarang City (1,533,686 people), Semarang Regency (921,865 people), Salatgia City (182,226 people). Furthermore, in 2019, the population of Semarang City (1,814,110 people), Semarang Regency (1,053,786 people), and Salatiga City (194,084 people). The study area map in Semarang can be seen in Fig. 1.

In obtaining data in the form of temperature distribution and community comfort index in the Semarang area, tools and materials are required as the primary components for data processing. This research employed tools and materials as in Table 1.

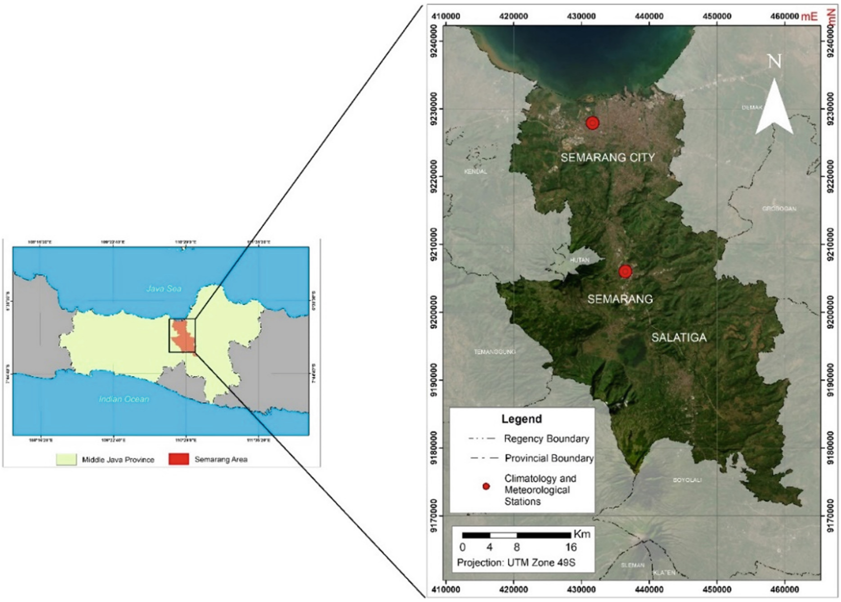


Fig. 1. Study location map

Table 1. Materials and research data sources

No.	Materials	Data sources
1.	Landsat 5 TM Satellite Imagery Data for Semarang Area in 1999 and 2009	Google Earth Engine
2.	Landsat 8 OLI Satellite Imagery Data for Semarang Area in 2019	Google Earth Engine
3.	Temperature Data for 1999, 2009, and 2019	Google Earth Engine
4.	Shapefile Data on District/City Administrative Boundaries and Provincial Administrative Boundaries in Indonesia in 2020	www.indonesia-geospasial.com
5.	Relative Air Humidity Data of Semarang Climatology Station, as well as SMPK Ungaran, Semarang Regency in 1999, 2009, and 2019	dataonline.bmkg.go.id, power.larc.nasa.gov

2.2 Data Analysis and Processing Techniques

The comfort level is influentially determined by two factors: temperature and humidity. Data on temperature were obtained by processing Landsat 5 TM imagery for the 1999 and 2009 imagery and Landsat 8 OLI imagery for the 2019 imagery. The use of the two Landsat imageries is because the research was conducted multi-temporally over several years to obtain parameters for change in each region. The studied years spanned the last ten years. The brightness temperature data is processed with Google Earth Engine through the brightness temperature formula, which is sequentially used to obtain temperature extraction. Radiometric and atmospheric corrections must be applied because atmospheric effects generally affect the imagery, resulting in suboptimal spectral reflections on objects. According to (Dewantoro et al., 2021), the Landsat 5 imagery and Landsat 8 imagery employed in Google Earth Engine are indirectly corrected radiometrically and atmospherically. Thus, these corrections are not repeated to avoid reflectance bias.

Google earth engine can compute clouds in imagery, so the resulting temperature imagery analysis has a better-sharpening level than conventional imagery data processing (Amelia et al., 2020). Cloud masking in the code is operated ('CLOUD_COVER', 10), which means that the employed imagery scene has a cloud cover condition of less than 10%. Thus, further data processing can be conducted. Before converting the pixel values, the selection of study locations is conducted in the script using the codes "ee.ImageCollection" and .filterdate to obtain the time range for imagery recording. The data processing on community comfort using the Temperature Humidity Index, there is a research flowchart in Fig. 2.

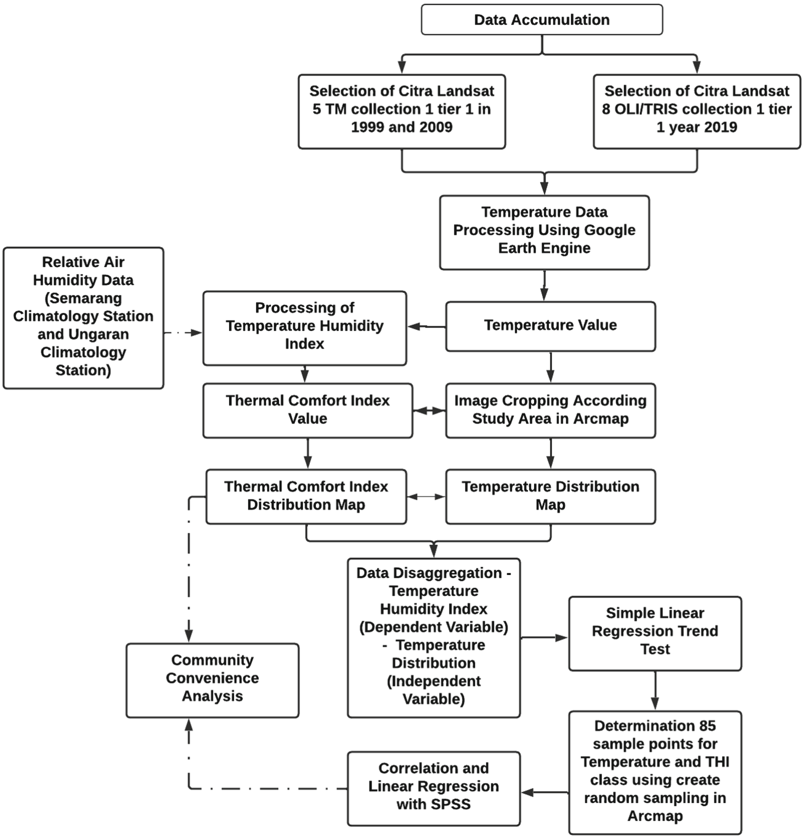


Fig. 2. Research Flowchart

Following the research flow chart in Fig. 2, the formula applied to convert the digital number into a radiation spectral value to obtain the temperature value is as follows.

$$L\lambda = (Mt)x\,Qcal + At \tag{1}$$

$$L\lambda = \left(\frac{Lmax\lambda - Lmin\lambda}{Qcalmax - Qcalmin}\right)x\,(Q\,cal - Q\,calmin) + Lmin \tag{2}$$

Description:
Mt: Scale Factor
At: Adding Factors
Lmaxλ: Maximum Spectral Radiance
Lminλ: Minimum Radiance Spectral
QCALmax: Minimum Total Number of Calibration Dns
Qcalmin: Maximum Total Number of Calibration Dns
QCAL: DN Calibration

The thermal band employed in the Landsat 5 TM imagery is in band 6 with a resolution of 120 m, and the wavelength is at 10.40–12.50 µm, while the Landsat 8 OLI imagery is located in band 10 with a resolution of 100 m and a wavelength of 10.60–11.19 µm for the thermal band specification. According to the formula above, the band is applied to convert pixel values into radiation spectral values. In obtaining the temperature value, further conversion is required to obtain the temperature value in Kelvin units. The formula used is as follows:

$$T = \frac{K2}{ln\left[\frac{K1}{L\lambda} + 1\right]} \tag{3}$$

Description:
T: Temperature (Kelvin)
Lλ: Thermal Radiance Band Value or Radiation Spectral Value
K1 Dan K2: Constants

The obtained temperature distribution values are in raster form but still in Kelvin units. Thus, adjustments are required by converting the unit values into Celsius form. The conversion of this value is conducted by reducing the digital number with the boiling point value in Kelvin units to the unit Celsius learning point value (373–100). The formula used is as follows:

$$\mathrm{T} = \mathrm{DN} - 273.15 \tag{4}$$

Information:
T: Temperature Value in Celsius
DN: Digital Number or Temperature Value Obtained in Kelvin

The formula for reaching the temperature value in Kelvin units to the temperature value in Celsius units, translated into the JavaScript programming language, is:

$$\begin{aligned}&\mathrm{return\ img.expression}\\&\left('((\mathrm{K2}/(\log(\mathrm{K1}/((\mathrm{TIR} * \mathrm{Mt}) + \mathrm{At}) + 1))) - 273.15)', \{'\mathrm{TIR}' : \mathrm{img}\}\right)\end{aligned} \tag{5}$$

This script can obtain raster temperature values in three related regions (Semarang City, Semarang Regency, and Salatiga City).

Data on average air humidity in the Semarang area was obtained through secondary data collected from the Meteorology, Climatology, and Geophysics Agency and Power Data Access meteorology and solar (NASA, 2022) in the local area. The utilized climatology stations were the Climatology Station of Central Java, Semarang, and SMPK Ungaran, Semarang. Air temperature has a significant impact on relative air humidity. Air humidity data were obtained for each year: 80.66% in 1999, 78.52% in 2009, and 74.97% in 2019. These three data are crucial parameters in determining the community comfort index distribution. Measurement of the comfort level, which is determined by the temperature and humidity factors, can be accomplished through the Temperature Humidity Index. The comfort index can be calculated using the equation according to Nieuwolt, 1977 in (Pertiwi & Paski, 2021), the applied formula is as follows:

$$\mathrm{THI} = 0,8\mathrm{Ta} + (((\mathrm{RH}\ \mathrm{X}\ \mathrm{Ta}))/500) \tag{6}$$

Description:

THI: Temperature Humidity Index (°C)

Ta: Air Temperature (°C)

RH: Air Humidity (%)

The comfort level classification is based on the comfort limits of Nieuwolt (1977) and Emmanuel (2005) in (Melinda, 2022), which have been adapted and modified to the climatic conditions found in the equatorial region, which is tropical climates. The THI value based on this classification is divided into three types, between <24 °C, defined as comfortable population, 25–27 °C, defined as moderately comfortable population; and >27 °C, defined as uncomfortable population.

Analysis of the relations between Temperature Distribution and Temperature Humidity Index was conducted quantitatively using a simple linear trend utilizing a sampling technique based on class levels, stratified random sampling (multilevel sampling of a population element) (Iliyasu & Etikan, 2021). Sample point measurements were conducted in Semarang City, Semarang Regency, and Salatiga City. There are 85 sample points employed, and the measurement of the sample points is based on the distribution of temperature and the Temperature Humidity Index. The distribution of the sample points was implemented using Arcmap 10.8 through the tools "create random points" and extract multi point values. The accuracy of the temperature distribution is important before determining the sample point by dividing the temperature distribution into five classes with 17 samples in each class to obtain the temperature characteristics according to the predetermined categories. The distribution of sample points in the region will be formed and determined automatically in the Semarang area, which is the main cluster area. The temperature value and comfort level will be obtained based on the pixel value at each sample point.

3 Results and Discussion

3.1 Distribution of Temperature and Community Comfort Index in the Semarang Area in 1999, 2009, and 2019

The temperature distribution is obtained based on Landsat imagery processing, which has previously been corrected to obtain appropriate imagery visualization for THI analysis purposes. The imagery applied is Multitemporal Imagery Types in 1999, 2009, and 2019. In 1999 and 2009, imagery data processing used Landsat 5 imagery, while in 2019, it used Landsat 8 imagery to obtain temperature values. Based on the data processing results for each thermal band (band 10 for Landsat 8 imagery, band 6 for Landsat 5 imagery), the lowest temperature value in the Semarang area is <23 °C, as seen in Fig. 3.

In contrast to the study conducted (Suyono & Prianto, 2018), which obtained temperature acquisition data by observing the different aspects of changes in comfort directly by grouping activities that affect the microclimate, it has not shown a spatial distribution of temperature. Temperature acquisition was conducted based on the visualization of the temperature distribution map in Fig. 3. High temperatures tend to begin in the northern coastal area of Semarang City, which moves southwards towards the eastern Semarang Regency area, where the area has a hilly topography dominated by residential areas that are directly adjacent to outside administrative areas of Semarang, such as Demak Regency, Grobogan Regency, and Boyolali Regency. Furthermore, it moves to the west, Salatiga City also recognized to have a high temperature. The Semarang City area is one of the areas with the most significant temperature increase. This condition is due to the function of Semarang City as the center of urban growth and the community socio-physical economic activities.

In accordance with the temperature distribution, community prefer to move to dense areas, symbolized in red, which means there is an increase in temperature in the area.

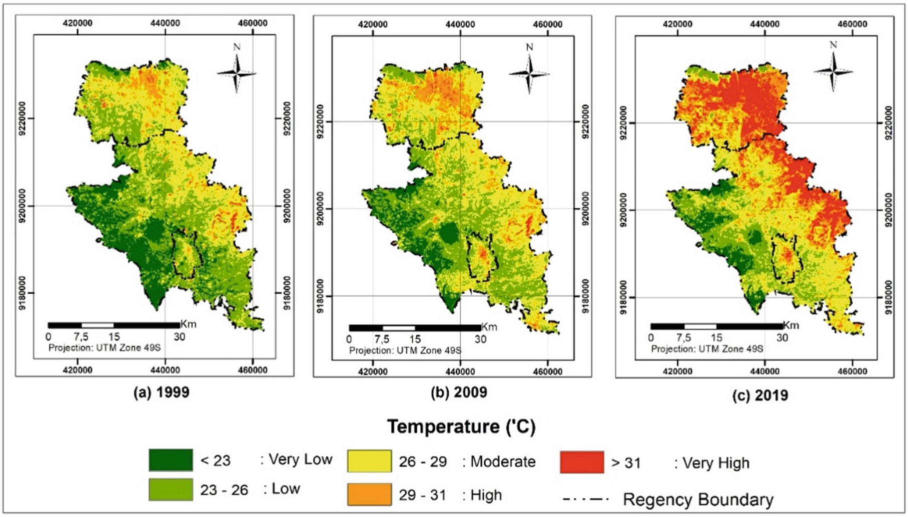


Fig. 3. Map of the distribution of temperature values

It corresponds to (Gómez & Barton, 2013), a large population who assemble in a place due to physical activity can reduce the temperature in the area. From 1999, the highest temperature was in the category of more than 31 °C, in which the highest temperature based on Fig. 3 was found at several points, such as the center of Semarang City, several parts of the center of Semarang Regency, including Ungaran, and several parts of the eastern area, such as Pringapus, Bringin, Bancak, Suruh, Susukan, and Kaliwungu. In 1999 most of the temperatures were in the very low to low category due to the lack of mobility and the small increase in the number of built-up areas.

Ten years later, in 2009, the increase in temperature began to increase. The distribution of the high-temperature category index began to spread to areas previously in the moderate category to the high category. This situation can be seen in the regional center, Semarang City. This increase occurred especially in the North Semarang area, which is a coastal area. It is recognized that the coastal area is a multifunctional area used as a port, a settlement, and a tourism area. Following the statement (Pahleviannur et al., 2020), the coastal area is an area that has various functions, such as administrative capital, settlements, industry, ports, aquaculture, agriculture, and tourism. The dominance of activities in the region, especially in Semarang City, having an international standard port, has added to the benefits of procuring goods distribution routes across the Semarang area. These conditions precisely increase the magnitude of the temperature in the City of Semarang.

The significant increase in temperature began to be sensed very high in 2019. Almost all areas of Semarang City have extremely high temperatures. Other areas, such as parts of the central and eastern Semarang Regency and Salatiga City, are also experiencing rising temperatures. The increasing rate of growth and the conversion of non-built-up land to built-up land are two causes of high temperatures in each of these areas as an effect of the high demand and activity of the community. This condition follows the statement (Sasmito & Suprayogi, 2017) which is influenced by infrastructure development such as ports, buildings, and busy community activities that increase the area's temperature. High temperatures are also discovered in the central region, a cluster area of hotel, administrative, shopping, and densely populated residential buildings. The influence of these temperature changes has an impact on the humidity value in the Semarang area. In the related three years, the humidity value has tended to decrease, resulting in a decrease in the comfort index. The reason is that this method is employed as a parameter to determine the impact of high-temperature distribution on human comfort by combining temperature and humidity factors (Andani et al., 2018). Temperature and humidity can be interpreted as having a direct relation when determining the comfort level depicted in Fig. 4.

Research on the comfort index THI values in the Semarang area was categorized into three types: comfortable, with a value of <24 °C; moderately comfortable, with a value of 24–27 °C; and uncomfortable category, with a value of >27 °C. 1999 was dominated by a low comfort index, which means that the area was still comfortable to live in because the temperature and humidity values were still good. There is still various vegetation, and there is no land conversion on a large scale, which balance the water vapor in the atmosphere (Deng et al., 2013). The amount of humidity in an area indicates that the air is moist. Each region has a different comfort index, which is influenced by the

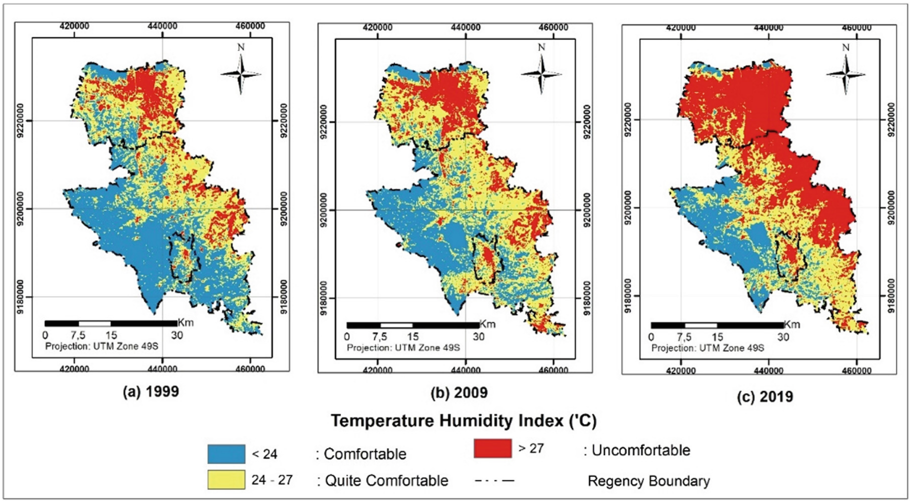


Fig. 4. Map of the comfort index distribution

humidity parameter caused by several factors, such as solar radiation, elevation, and wind speed influence (Niu et al., 2015). Air humidity tends to be higher during the day due to evapotranspiration from the surface. Therefore, the THI value is considerably more optimal because the soil absorbs solar radiation during the day. When the temperature increases, people do numerous activities, resulting in a high comfort index. Occasionally, especially from morning until noon, people in community tend to be excited, so during this period, an increase in temperature begins to be experienced and impacts the comfort conditions of each individual (Gallardo et al., 2016). The THI value represents a high value, meaning that the area has a low comfort level, resulting in a less comfortable area for people to live in and vice-versa.

Referring to the visualization of the comfort index distribution map in Fig. 4, it is not much different from the temperature value; the comfort index value in the Semarang City area is extremely high, which means that the area is in the uncomfortable category. In addition, parts of Semarang Regency and Salatiga City have also experienced significant growth in their comfort index over the past 20 years. In fact, in 2019, almost all areas of Semarang City are in the comfort level category of >27 °C, which can be classified as the most uncomfortable area of the two surrounding areas. The southern region, especially the western part of Semarang Regency, is dominated by highlands. Thus, it has a high comfort level due to the more stable temperature and humidity conditions. It can also be indicated that this area has a higher distribution of vegetation. According to (Isnoor et al., 2021), the increase in the value of the comfort index can be anticipated by adjusting the air temperature, where humans can naturally adapt to high outside temperatures. In contrast, it depends on the human ability to adapt to the surrounding environment. Suppose temperatures continue to increase yearly and human adaptability is insufficient to accept changing conditions. In that case, it will indirectly result in a fatal risk for the individual's physical and mental condition.

3.2 Trends in Community Comfort from Several Years Based on THI Area Level

The community comfort index based on the THI area value in the Semarang area shows an increase and decrease yearly. This condition can be seen from the comfort index in the three related areas. It should be noted that the class classifications in the graph are based on the level of comfort based on the area of THI. Class 1 is a class with a comfortable category; class 2 is moderately comfortable; and class 3 is a class with the most uncomfortable category. It can be seen that the highest comfort index is in class 1. The temperature and humidity parameters of the area concerned also influence it. The area included in class 1 is an area with hilly topography where there is still numerous vegetation in it. Semarang Regency and parts of Salatiga City are still classified as class 1, having the lowest comfort index, which means that comfort in these areas tends to be high. Rural social conditions still dominate the social conditions of the community in the area; numerous people in community are still conducting agricultural activities. Thus, the comfort index in this class is quite significant in the Semarang Regency area. Through these conditions, indirectly, people in community can live comfortably in cool air (Wibawa, 2020). The comfort index area in class 1 then decreased in 2009 to 48721.2 ha, which had previously reached a value of 69799.5 ha. The downward trend in this class continued to the last year in 2019. The area of the comfort index in the same class reached 29847.7. The difference in the area of the comfort index can be seen further in Fig. 5.

The determination of the thermal comfort index is dominated by indoor studies. The outdoor comfort index study tends to refer to the comfort index according to the thermal sensation response discovered in an area, as in the study (Corgnati et al., 2009). This study focused on the community comfort index based on climatic conditions in the form of temperature and comfort values broadly regarding the Temperature Humidity Index (THI) processing to determine the comfort level of the region. The most significant increase in the THI area was presented to occur in class 3, in which this increasing trend occurred in the uncomfortable category in the three related years. The earlier the year, the lower the level of comfort. Compared to 1999, the THI area was still at 20219.8 ha,

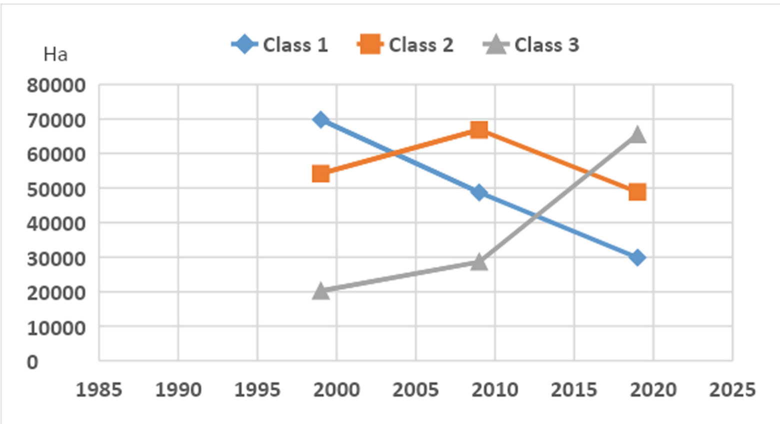


Fig. 5. Graph of temperature humidity index area in 1999, 2009, and 2019

then increased by 8396.4 ha to 28616.3 ha, and reached its highest point in 2019 with a 65481.7 ha area.

The increase and decrease in the THI area are influenced by temperature and humidity due to reduced vegetation in the Semarang area. Air atmospheric conditions change through the amount of vegetation, which can directly or indirectly affect the air in an area (Pietersz et al., 2018). Vegetation is one of the engineering controls for urban environmental problems, such as reducing air pollution that trigger high temperatures, especially in urban areas and their surroundings. The reduced vegetation is also triggered by the large surface hardened into a built-up area. This statement follows (Bozdogan et al., 2021), increasing built-up land or hardened objects, which increase temperature conditions. These objects also result in trapping heat bound by large amounts of pollutant gases, which generate an uncomfortable effect in an area. The decrease in the comfort index can indirectly increase the discomfort for the people in the Semarang area. The hot air temperature is narrowing the activities of the Semarang area community, where changes in the outdoor environment's climate controllers, such as vegetation, have begun to decrease, which causes the coolness in the area also to decrease.

3.3 Correlation and Regression Between Temperature and Temperature Humidity Index Results

Humidity affects the size of the microclimate in an area, especially in the Semarang area. This condition is caused by the presence of vegetation, which contributes to physiological processes such as photosynthesis and evapotranspiration, which can affect temperature, especially humidity in the surroundings (Pambudi et al., 2018). The increase in the total population and the imbalance of land specifically designated for residential areas results in reduced vegetation land, which affects the humidity value, as shown in Table 2.

Relative humidity in the Semarang area has decreased over the last 20 years. The air humidity data in the study location is based on two meteorological and climatological stations: The Semarang climatology station and SMPK Ungaran, Semarang. In these data, the highest average humidity was in 1999, with the two stations obtaining 80.66%. Regarding the increasing years, the humidity value in the Semarang area has decreased. In 2009, the relative air humidity reached an average total of 78.52%, and in 2019, it reached an average total of 74.97%. The influence of the humidity value is very significant in determining the temperature and THI values, as seen in Table 3 and Table 4.

Table 2. Relative Air Humidity for the Semarang Area in 1999, 2009, and 2019 (Semarang Climatology Station and SMPK Ungaran Semarang in 1999, 2009, 2019, and power.larc.nasa.gov)

Station	Humidity 1999 (%)			Humidity 2009 (%)			Humidity 2019 (%)		
	Min	Max	Average	Min	Max	Average	Min	Max	Average
Climatology Station, Semarang	59.4	88.4	79.4	63.1	89.2	76.7	55.3	85.7	72.7
SMPK Ungaran, Semarang	61.1	90.5	81.8	62.5	88.8	80.3	60.2	88.6	77.2

Table 3. One Sample Kolmogorov-Smirnov Test and Correlations

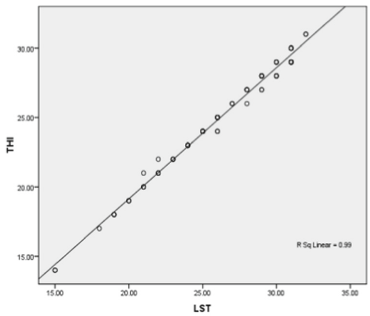
Parameters	1999		2009		2019	
	T	THI	T	THI	T	THI
N	85	85	85	85	85	85
Kolmogorov-Smirnov Z	1.271	1.298	1.321	1.227	1.236	1.023
Asymp. Sig. (2-tailed)	0.079	0.069	0.061	0.098	0.094	0.246
Test Distribution	Normal		Normal		Normal	

Table 4. Correlations between temperature and temperature humidity index (THI)

Parameters		1999		2009		2019	
		T	THI	T	THI	T	THI
T	Pearson Correlation	1	0.995	1	0.993	1	0.994
	Sig. (2-Tailed)		0.000		0.000		0.000
	N	85	85	85	85	85	85
THI	Pearson Correlation	0.995	1	0.993	1	0.994	1
	Sig. (2-Tailed)	0.000		0.000		0.000	
	N	85	85	85	85	85	85

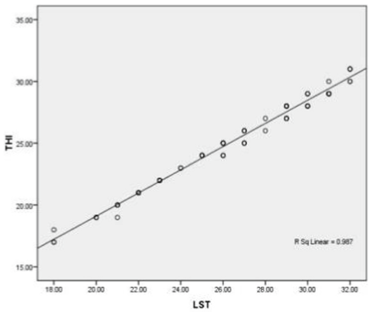
The relation between (T) temperature and the Temperature Humidity Index (THI) can be obtained through the correlation obtained by plotting 85 sample points in each study area. The type of sampling was stratified random sampling, which took samples based on the class strata or level in each class. Temperature functions as an independent variable with a total of 5 classes with 17 samples in each category of strata range. The normality test results are seen through the Kolmogorov-Smirnov test sample in the Asymp table. Sig 2 tailed on both x and y variables. Based on Table 3 Tests conducted in 1999, 2009 and 2019 showed that the residual data could be normally distributed. This relations can also be seen based on Table 4, from the Pearson correlation of 0.995 in 1999, which showed that an increase in temperature increases the THI value, which follows (Ayubi et al., 2022) the asymp value. Sig-2 tailed can be normal if the normality test reaches a value above 0.05. In 2009, the relations between increasing temperature and THI occurred with a Pearson correlation number of 0.993 and increased again to 0.994 in 2019.

Considering from the figure asymp. Sig 2 tailed shows the number 0.05 according to Sugiyono (2017) in (Fadilah & Nuryono, 2017) stated that this value includes the H0 value or the value of the relations between temperature and THI in conditions of normal distribution, and the temperature has a significant influence on the comfort index value in the Semarang area. The coefficient of determination based on the graph was discovered in 1999. In addition, the coefficient value of the adjusted r square reached 0.990, or it



Y = 0.227 + 0.946 x

Fig. 6. Scatter Plot Linier Regression Temperature & THI 1999



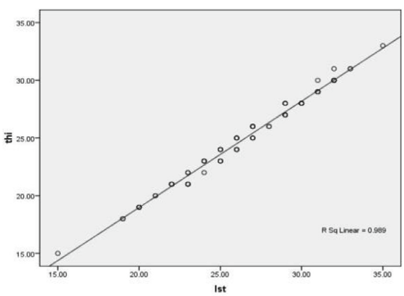
Y= 0.377 + 0.937 x

Fig. 7. Scatter Plot Linier Regression Temperature & THI 2009

can describe the variation of the average Temperature Humidity Index of 99% in general (see Fig. 6). It also applies to the adjusted r square coefficient of 96.7% in 2009 (see Fig. 7) and the adjusted r square coefficient of 98.9% in 2019 (see Fig. 8).

Furthermore, the linear regression curves for the three years present the distribution of points according to the linear or diagonal lines. It is also adequate to prove that the data is normally distributed. The values of the data plot points form a straight line pattern from the bottom left up to the top right, indicating a linear and positive relations between the two variables (temperature and THI). The positive relations graph also means that if the temperature in the Semarang area increases, the comfort index will also increase. It also applies to the community comfort index, which is in line with changes in temperature and humidity based on the thermal comfort value with the Semarang area's Temperature Humidity Index.

The lack of vegetation in some areas must be idealized to reduce the amount of distribution of uncomfortable THI values. The use of elements, or elements of both green open spaces or vegetated central areas, must be accomplished to increase cool climate conditions and can reduce temperature increases. Increasing the vegetated area



Y= 0.561 + 0.921x

Fig. 8. Scatter Plot linier regression Temperature & THI 2019

in an area will increase the temperature quality due to opening up carbon absorption areas in the air. Vegetation is the main factor in establishing comfort. Thus, the importance of developing and building vegetated areas is very effective and efficient in areas categorized as uncomfortable, especially in activity center areas such as Semarang City, Salatiga City, and parts of eastern Semarang Regency. The balance between types of land cover must be maintained, between built-up land, non-built-up land, and vegetated land, to increase the comfort index of the community, especially those living in the Semarang area.

4 Conclusions

The Semarang area with the highest temperature distribution at 31 °C is found in Semarang City, East Semarang Regency, and Salatiga City, while the lowest temperature is in the western Semarang Regency with a temperature range of <23 °C–29 °C. The earlier the year, the distribution of the thermal comfort index in each area reaches 24 °C to <27 °C due to the change of vegetation land into hard surfaces (built-up land). The great number of tall buildings not matched by good direction and vegetation factors makes urban community less comfortable to live in because of the relatively high temperatures. There was a downward trend in the Temperature Humidity Index class that continued until the last year, in 2019, in class 1. It is the class with a comfortable category, reaching 29848.7 ha, which had previously reached 69799.5 ha (1999) and 48721.2 ha (2009). This decrease is inversely proportional to the effect of discomfort on community living in the Semarang area. Correlation and regression testing prove that the residual data is normally distributed and that there is a positive linear relation between the two variables (temperature and THI). This relation shows that an increase in temperature also increases the value of the comfort index in the Semarang area and affects the comfort level for people to do activities. This research requires further research, especially regarding the amount of land use managed to determine the central vegetated area, such as green open spaces in the Semarang area, viewed from the land cover of the built-up areas used. It is significant to accomplish, considering the need to maintain the balance of the comfort index of the community who live in the Semarang area.

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