

Geoinformatics Heat Hazards Threat Based on Local Climate Zone.

Adi Wibowo (✉ adi.w@sci.ui.ac.id)

University of Indonesia Faculty of Mathematics and Natural Sciences: Universitas Indonesia Fakultas Matematika dan Ilmu Pengetahuan Alam <https://orcid.org/0000-0002-3946-0026>

Tristan Dimastyo Ramadhan

University of Indonesia: Universitas Indonesia

Iqbal Putut Ash Shidiq

Universitas Indonesia Fakultas Matematika dan Ilmu Pengetahuan Alam

Fatwa Ramdani

Tsukuba International School

Research Article

Keywords: Land surface temperature, land cover change, spatial-temporal analysis

Posted Date: March 6th, 2023

DOI: <https://doi.org/10.21203/rs.3.rs-2527877/v1>

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Abstract

Sumedang Regency has experienced considerable development in recent times. They started by expanding residential areas and toll roads to construct the Jatigede Dam. Changes in land cover may influence the temperature above and around it. This study aims to analyze the spatial pattern of surface temperature in Sumedang Regency between 2007-2022 based on land cover changes regarding the Local Climate Zone and heat hazard threat. The data used are Landsat TM, Landsat OLI/TIRS, and Landsat OLI-2/TIRS-2 images. The data is taken and processed using Google Earth Engine. The results found an increase in LST from 2007 until 2022, with the most significant increase occurring in 2022. This increase is accompanied by changes in land cover in Sumedang Regency. Land surface temperatures in Sumedang Regency have continued to increase from 2007 until 2022, and based on the observed urban heat signature, the most significant increase in average temperature occurred from 2007 to 2022 (4.68°C). The strong heat stress category can cause dynamic thermal sensation (DTS), a core-to-skin, and an increase in rectal temperature. Extreme heat stress can cause an increase in rectal temperature time gradient, a steep decrease in total net heat loss, and a steep increase in average sweat rate.

1. Introduction

The pattern of development that occurs in the world is driven by migration flows between rural and urban areas (Zhang et al., 2022). Migration in cities around the world triggers land changes that exceed the Environment's and humans' capacity to accommodate and plan good spatial planning (Kouassi et al., 2021). These changes can affect the region's temperature and cause local warming (Wong & Yu, 2005; Srivanit & Hokao, 2013; Wibowo & Salleh, 2018). This warming on a local scale can be detected using satellite sensors which are often used to see patterns of Land Surface Temperature (LST) or surface temperature (Kumar et al., 2022; Sahani, 2021; Cilek & Cilek, 2021). Variation of surface temperature in various urban landscapes is strongly influenced by the dominant land cover and land use in the region (Njoku & Tenenbaum, 2022).

One of the significant developments that occurred from 2007 to 2022 was the construction of the Jatigede Dam, the second-largest Dam in Indonesia. The Dam's construction is part of Presidential Regulation No. 3/2016 on the Acceleration of Implementation of National Strategic Projects. The Jatigede Dam changed the land cover by 4,980.3 ha, of which 1,400 ha was paddy fields (Simangunsong & Kurnia, 2018). The change in land cover is likely to influence the temperature above and around it (Kum, 2016). Given the different nature of water bodies compared to land cover (Lykins, 2011). Construction began in 2008 and was inaugurated in 2017 (Sumedang District Archives and Library Office, 2022), which has Jatigede Dam on the Cimanuk River with a capacity of 979.5 million m³. In 2016, the construction of the toll road Cisumdawu (Cileunyi–Sumedang–Dawuan) also started and passed through Sumedang Regency.

Geospatial technology has been used for various sectors. One of the most common methods is observation through remote sensing (Njoku & Tenenbaum, 2022; Amliana et al., 2016; Ashok et al., 2021; Avdan & Jovanovska, 2016). Geospatial information has primarily developed within the context of an emerging discipline, named Geoinformatics, Geomatics, or Geographic (sometimes Geospatial) Information Sciences (Chandarasekaran & Arivarignan, 2006). Geomatics is derived from the French word *Ge'omatique*, coined by the French photogrammetric Dubuisson and widely used in North America (Ehler, 2008)]. Geoinformatics seems popular in Europe, whereas Geographic Information Science usually indicates a Geography background (Goodchild, 1992). Remote sensing uses electromagnetic radiation sensors to record images of the earth's Environment that can be interpreted to produce helpful information (Read & Torrado, 2009). Utilization of image results captured by satellites with different sensors (such as TM, OLI, TIRS) has an excellent ability to determine surface characteristics by using reflected waves at specific wavelengths (Kumar et al., 2022; Acharki, 2022; Thenkabail et al., 2005). Calculating an area's land surface temperature can determine these surface characteristics. Therefore, this method is used for the Sumedang Regency area, which experienced considerable development during the time frame of this study. This study aims to analyze the spatial pattern of surface temperature in Sumedang Regency between 2007 and 2022 (15th year) based on land cover changes regarding the Local Climate Zone and heat hazard threat.

2. Methodology

2. 1. Study Area And Data

Sumedang Regency is an area dominated by forests and agriculture with 26 districts (Fig. 1). The absolute location of this regency is 6°44'–70°83' south latitude and 107°21'–108°21' east longitude with an average altitude of 999 meters above sea level. Sumedang Regency is located in tropical latitude and experiences two seasons: dry in (June, July, and August) and wet in (December, January, and February). The intensity of solar radiation is affected by El Nino and La Nina phenomena (Hamdi & Sumaryati, 2020).

2.2. Landsat Data

This study uses Landsat Data Collection 1 Tier 1 Top of Atmosphere Reflectance with 30-meter spatial resolution obtained from the United States Geological Survey (USGS). The Landsat images in 2007, 2013, 2017, and 2022 were sorted to find the least percentage of cloud cover. Data was used from the Landsat Series in June, July, and August. The images used in this study are 7 Landsat-5 TM images for 2007, 9 Landsat-8 OLI/TIRS images for 2013, 12 Landsat-8 OLI/TIRS images for 2017, and 11 Landsat-9 OLI-2/TIRS-2 for 2022. Google Earth Engine is used to correct, calibrate and process these images (Hamdi & Sumaryati, 2020).

2.3. Local Climate Zone Mapping

In this study, the multiband (band 1–7) Landsat 8 remote sensing data was retrieved and classified by utilizing the online cloud platform Google Earth Engine (GEE) (Ernida et al., 2020). The GEE uses to retrieve the land surface temperature (Roy & Bari, 2022). The training sample area within the ROI was digitized from the Landsat 8 guided by the google earth view. There are 170 training area samples for all 17 classes of LCZ (10 samples for each class). Then, the rest of the area in ROI is classified by the random forest (RF) machine learning classifier. To validate the accuracy of the RF algorithm then, cross-validation was conducted in this study. 70% of the training sample data are used for building the model, and 30% of the sample is used for validation. The performance of the RF algorithm was evaluated from the value of overall accuracy (OA) (Fig. 2).

2.4. LST Retrieval

A single-channel approach using Band 10 of Landsat 8 was used to retrieve land surface temperature (LST) from thermal infrared data (Weng & Schubring, 2004)]. The procedures consist series of conversions, including digital numbers to radiances, radiances to brightness temperatures, and finally, brightness temperature to land surface temperature (emissivity correction). These methods were also requiring normalized difference vegetation index (NDVI). NDVI value of 0.2 was used for a pure soil pixel and 0.5 for a pure vegetation pixel. LST obtained from the study area's urban canopy layer, and surface material Landsat-8 shows the current condition of the urban canopy layer and surface material in the study area. The LST calculation is carried out in Eq. 1. (Guha et al., 2022).

$$LST = \left(\frac{T}{1 + (\lambda \sigma T / (hc)) \ln \epsilon} \right) - 273.15$$

1

Where λ is the wavelength; σ is the Boltzmann constant ($1,38 \times 10^{-23}$ J/K); h is Plank's Constant (6.626×10^{-34} Js); c is the speed of light in a vacuum (2.998×10^{-8} m/s); the value is converted from kelvin to Celsius by subtracting 273.15.

2.5. Universal Thermal Climate Index (UTCI)

The Universal Thermal Climatic Index, or UTCI, is an index developed to observe the effect of environmental temperature on humans (Zare et al., 2018a; Błażejczyk, 1994). This index can provide information about the human response to specific temperature conditions in several ranges of index values (Park et al., 2014). Several parameters estimate UTCI: dry temperature, average radiation temperature, water vapor pressure or relative humidity, and wind speed (Zare et al., 2018). This index is considered one of the best indicators for calculating outdoor heat stress (Błażejczyk, 1994).

In this study, not all UTCI categories were used. Only 5 out of 10 categories are used according to the temperature in the study area. The five categories are:

- Extreme Heat Stress (> 46°C)

- Very Strong Heat Stress (38°C to 46°C)
- Strong Heat Stress (32°C to 38°C)
- Moderate Heat Stress (26°C to 38°C)
- No Thermal Stress (9°C to 26 °C).

3. Results And Discussion

3.1. Local Climate Zone

The Local Climate Zone (LCZ) is an urban land classification system based on cities' morphological characteristics, including building structures, materials, and land cover types (Cardoso et al., 2018). Local Climate Zones describe areas with uniform land cover, structures, building materials, and human activities within 100 meters to several kilometers (Stewart et al., 2014). The 17's Local Climate Zones consist of 10 building classes and 7 land cover classes (Fig. 3). Each type of Local Climate Zone represents microclimatic conditions based on the temperature response to the city structure (Aslam & Rana, 2022).

Sumedang has various land covers with major vegetated areas. The division of LCZ classes has only 11 divisions spread throughout Sumedang. However, based on the composition area distribution, Sumedang is dominated by LCZ type A (Natural Landscape. LCZ 6 and LCZ 3 was the predominant class covering up to 30% of the region. LCZ 6 (open low-rise) and LCZ 3 (compact low-rise). Comparison between built-up area (LCZ 1–10) and natural landcover type (LCZ A-G) is starkly different. The built-up area occupies 20% of the total area. Meanwhile, natural land cover only takes 80% (Table 1). Dense trees covered almost 85.4% or a total of 1,357.49 Km².

Table 1
LCZ Sumedang Regency

LCZ	Type	Area (km ²)	Percentage (%)
1	Compact High Rise	0.01	0.00
2	Compact Midrise	0.00	0.00
3	Compact Low Rise	17.23	1.08
4	Open High-Rise	0.00	0.00
5	Open Midrise	0.00	0.00
6	Open Low-Rise	66.11	4.15
7	Lightweight low-rise	0.00	0.00
8	Large low-rise	4.66	0.29
9	Sparsely built	0.00	0.00
10	Heavy Industry	5.22	0.33
A	Dense Trees	1,357.49	85.24
B	Scattered Trees	0.00	0.00
C	Bush, Scrub	0.00	0.00
D	Low Plants	16.02	1.01
E	Bare Rock or Paved	0.00	0.00
F	Bare Soil or Sand	101.65	6.38
G	Water	24.02	1.51
Total Areas		1,592.40	100.00
Source: Data Processing			

3.2. Land Surface Temperature

The land surface temperature in Fig. 1. is shown in the range of 15°C to 45°C. Since each map has a time interval of 4–5 years, LST shifts are visible. The areas in white colored are masked clouds, so they are not included in the analysis. The 2017 map has a lot of cloud cover compared to other maps. Nonetheless, this is not too significant because there is not much change in the southern part, considering that the southern part is the foothills of Mount Kerenceng, which is dominated by high-density forests. The most highlighted area is the Northeastern part of the Sumedang Regency. Based on observations via Google Earth, the area is dominated by paddy field land use. There is no significant addition of new buildings in the area. However, this region will have high and worsening temperatures in

2022. Next is an area with urban characteristics, namely Sumedang Utara District, which experiences a constant increase in temperature from year to year. This increase occurred due to the phenomenon of urban sprawl. The development of the area widened, especially towards the South and North. These phenomena were seen on the Southwestern border of Sumedang Regency, which was laid in Cimanggu and Cikeruh District. The two districts were additional built-up areas, like housing, factories or warehouses, and toll roads. Therefore, temperature increases (Shidiq et al., 2020; Tran et al., 2017).

The area change in LST was done around the Jatigede Dam. The Dam can be seen in the 2017 and 2022 images. Previously, this Dam was a paddy field and housing. Since the Dam's existence, the area above the Dam has experienced a decrease in temperature. However, the surrounding area experienced a temperature rise. Nevertheless, this does not determine a correlation between the large Dam and the temperature around it because a change in land cover also comes with it (Degu et al., 2011; Kum, 2016). (Table 2).

Table 2
LST 2007–2022 on Sumedang Regency

LST (°C)	2022 Area (km ²)	2022 Percentage (%)	2007 Area (km ²)	2007 Percentage (%)
< 23	0,88	0,27	39,53	11,99
23,1–26,9	20,49	6,20	62,13	18,8
27–30,8	55,20	16,70	134,86	40,91
30,9–34,6	89,31	27,00	74,33	22,5
34,7–38,5	96,83	29,37	15,72	4,77
38,6–42,4	41,76	12,67	2,43	0,74
42,5–46,3	16,90	5,13	0,04	0,01
> 46,4	1,96	0,60	0,01	0,00
Source: Data analysis				

3.3. Temporal Analysis of LST

The average land surface temperature in the study area has increased from 2007 to 2022. The most considerable increase occurred from 2017 to 2022. The temperature increased to 4.68°C. The maximum temperature tends to increase yearly, although decreased from 2007 to 2013, while the minimum temperature is relatively stable, and the highest standard deviation occurred in 2022. The temperature distribution is normally distributed, and every year the curve shifts towards higher temperatures. A significant change occurred in 2022. Apart from being marked by an average temperature increase of

4.68°C, the standard deviation is also the largest. This standard deviation indicates a relatively even distribution of temperature units compared to previous years. More details can be seen in Fig. 7.

3.4. Urban Heat Hazard

The land surface temperature is divided into five categories based on UTCI, and the transformations from year to year can be seen in Fig. 3. The hazards occurred in 2012 and 2013, with stress categories from strong heat stress to extreme heat stress. Extreme heat stress only had a small portion from 2007 to 2022 (0.15 km², 0.21 km², and 0.08 km², respectively), but in 2022 this category rose to 11.78 km². The same thing happened in the very strong heat stress category. The area of this category increased almost tenfold from 36.22 km² to 354.18 km² from 2017 to 2022. Meanwhile, the strong heat stress category increased slowly compared to the previous two classes. The moderate heat and no thermal stress categories tend to experience a decrease in the area each year. The decrease in the moderate category from 2007 to 2022 reached 436.1 km². The no thermal stress category decreased from 2007 to 2022, reaching 323.5 km². The fluctuations based on UTCI can be seen in Fig. 8.

Table 3
Variation of land surface temperature area based on UTCI

Heat Stress Category	2007 (km ²)	2022 (km ²)	(+/-)
<i>Extreme Heat Stress (> 46°C)</i>	<i>0.15</i>	<i>11.79</i>	<i>+ 11.64</i>
<i>Very Strong Heat Stress (38°C to 46°C)</i>	<i>17.10</i>	<i>354.18</i>	<i>+ 337.08</i>
<i>Strong Heat Stress (32°C to 38°C)</i>	<i>318.77</i>	<i>736.00</i>	<i>+ 417.23</i>
<i>Moderate Heat Stress (26°C to 38°C)</i>	<i>775.91</i>	<i>339.81</i>	<i>-436.10</i>
<i>No Thermal Stress (9°C to 26 °C)</i>	<i>400.09</i>	<i>76.59</i>	<i>-323.50</i>
Source: Analysis Data			

Related to LST, the distribution of UTCI also changes every year. Heat stress levels increased in activity centers such as in North Sumedang District. This heat level is dangerous, considering the densely populated area (Wibowo et al., 2016). The intense heat stress category can cause dynamic Thermal Sensation (DTS), an average sweat rate of more than 200 g/h, an increase in rectal temperature at 120 min, latent heat loss, and instantaneous changes in skin temperature (Błażejczyk et al., 2013). Then the very strong heat stress category can cause a core-to-skin temperature gradient < 1K (at 30 min) and an increase in rectal temperature at 30 min (Błażejczyk et al., 2013). Finally, extreme heat stress can cause an increase in rectal temperature time gradient, a steep decrease in total net heat loss, and a steep increase in average sweat rate > 650 g/h (Błażejczyk et al., 2013). The distribution of hazardous areas based on UTCI year 2007 can be seen in Fig. 9 and UTCI Sumedangnn regency year 2022 in Fig. 10.

Land surface temperatures in Sumedang Regency have continued to increase from 2007 and 2022. Temperature increases on the border in the Northeast, Southwest, and North Sumedang Districts. Based on the observed urban heat signature, part of the cause of the temperature change is due to construction (housing, factories or warehouses, and toll roads). The most significant increase in average temperature occurred from 2017 to 2022 (4.68°C). The strong heat stress category (736 km² in 2022) can cause dynamic thermal sensation (DTS), averaged sweat rate of more than 200 g/h, an increase in rectal temperature at 120 min, latent heat loss, and instantaneous changes in skin temperature (Błażejczyk et al., 2013). Then the very strong heat stress category (354.18 km² in 2022) can cause a core-to-skin temperature gradient < 1K (at 30 min) and an increase in rectal temperature at 30 min (Błażejczyk et al., 2013). Finally, extreme heat stress (11.79 km² in 2022) can cause an increase in rectal temperature time gradient, a steep decrease in total net heat loss, and a steep increase in average sweat rate > 650 g/h (Błażejczyk et al., 2013).

4. Conclusions

The Local Climate Zone (LCZ) in Sumedang Regency has 8 classifications. The highest building density is in the low-rise compact LCZ. The maximum vegetation density is in the LCZ dense tree with forest and, on the other hand, the highest LST in the open low-rise zone with residential land use with relatively high human intensity. The LCZ is characterized by built-up land with medium density located in the center. The results found an increase in LST from 2007 until 2022, with the most significant increase occurring in 2022. This increase was accompanied by changes in land cover in Sumedang Regency. The construction of toll roads has led to a substantial rise in LST. Land surface temperatures in Sumedang Regency have continued to increase from 2007 until 2022, and based on the observed urban heat signature, the most significant increase in average temperature occurred from 2007 to 2022 (4.68°C). The strong heat stress category can cause dynamic thermal sensation (DTS), averaged sweat, and the very strong heat stress category can cause a core-to-skin and an increase in rectal temperature, and extreme heat stress can cause an increase in rectal temperature time gradient, a steep decrease in total net heat loss, and a steep increase in average sweat rate.

Declarations

Acknowledgment

This research and published paper is supported by Research Grant PUTI RA 2022 from The Directorate of Research and Development Universitas Indonesia 2022.

Funding

"This work was supported by [Research Grant PUTI Q2 2022 from The Directorate of Research and Development Universitas Indonesia] with Grant numbers [NKB-639/UN2.RST/HKP.05.00/2022]"

Competing Interests

"The authors have no relevant financial or non-financial interests to disclose."

Author Contributions

All authors contributed to the study's conception, idea, and design. Material preparation, data collection, and analysis were performed by [Adi Wibowo] and [Tristan Dlmastyo Ramadhan]. The first draft of the manuscript was written by [Tristan Dimastyo Ramadhan] and [Adi Wibowo], and The other authors [Iqbal Putut Ash Shidiq] and [Fatwa Ramdani] commented and critically revised the draft paper. All authors read and approved the final manuscript.

Ethical Statement

All authors stated that this paper is only this journal and stated there is no conflict of interest.

References

1. Acharki, S. (2022). PlanetScope contributions compared to Sentinel-2 and Landsat-8 for LULC mapping. *Remote Sensing Applications: Society and Environment*, 27, 100774. <https://doi.org/10.1016/j.rsase.2022.100774>
2. Amliana, D. R., Prasetyo, Y., & Sukmono, A. (2016). Analisis Perbandingan Nilai NDVI Landsat 7 dan Landsat 8 pada Kelas Tutupan Lahan (Studi Kasus: Kota Semarang, Jawa tengah). *Jurnal Geodesi UNDIP*, 5(1), 264–274.
3. Ashok, A., Rani, H. P., & Jayakumar, K. V. (2021). Monitoring of dynamic wetland changes using NDVI and Nddddddd Landsat imagery. *Remote Sensing Applications: Society and Environment*, 23, 100547. <https://doi.org/10.1016/j.rsase.2021.100547>
4. Aslam, A., & Rana, I. A. (2022). The use of local climate zones in the urban Environment: A systematic review of data sources, methods, and themes. *Urban Climate*, 42, 101120.
5. Avdan, U., & Jovanovska, G. (2016). Algorithm for automated mapping of land surface temperature using LANDSAT 8 satellite data. *Journal of Sensors*, 2016, 1–8. <https://doi.org/10.1155/2016/1480307>
6. Błażejczyk, K. (1994). New climatological and physiological model of the human heat balance outdoor (MENEX) and its applications in bioclimatological studies in different scales. *Zeszyty Instytutu Geografii i Przestrzennego Zagospodarowania PAN*, 28, 27–58.
7. Błażejczyk, K., Jendritzky, G., Bröde, P., Fiala, D., Havenith, G., Epstein, Y., Psikuta, A., & Kampmann, B. (2013). An introduction to the Universal Thermal Climate Index (UTCI). *Geographia Polonica*, 86(1), 5–10. <https://doi.org/10.7163/gpol.2013.1>
8. Cilek, M. U., & Cilek, A. (2021). Analyses of land surface temperature (LST) variability among local climate zones (LCZs) comparing Landsat-8 and ENVI-met model data. *Sustainable Cities and Society*, 69, 102877. <https://doi.org/10.1016/j.scs.2021.102877>

9. Chandarasekaran S. K., and Arivarignan G. (2006) Disease mapping using mixture distribution, *Indian Journal of Medical Research*, Vol.123 Issue 6, pp. 788-798
10. Cardoso, S R., Amorim, M. C., Liu, D., & Montenegro, A. (2018) Using High-Resolution Satellite Imagery To Characterize Local Climate Zones In Presidente Prudente, Brazil, 156.
11. Degu, A. M., Hossain, F., Niyogi, D., Pielke, R., Sr., Shepherd, J. M., Voisin, N., & Chronis, T. (2011). The influence of large dams on surrounding climate and precipitation patterns. *Geophysical Research Letters*, 38(4), n/a-n/a. <https://doi.org/10.1029/2010gl046482>
12. Ehler M., (2008). Geoinformatics and digital earth initiatives: a German perspective, *International Journal of Digital Earth*, Vol. 1, Issue 1, pp. 17-30.
13. Ermida, S. L., Soares, P., Mantas, V., Göttsche, F.-M., & Trigo, I. F. (2020). Google earth engine open-source code for land surface temperature estimation from the Landsat series. *Remote Sensing*, 12(9), 1471. <https://doi.org/10.3390/rs12091471>
14. Goodchild M.F. (1992). Geographical Information Science, *International Journal of Geographical Information Systems*, Volume 6, Issue 1, pp. 31-45.
15. Guha, S., Govil, H., Taloor, A. K., Gill, N., & Dey, A. (2022). Land surface temperature and spectral indices: A seasonal study of Raipur City. *Geodesy and Geodynamics*, 13(1), 72–82. <https://doi.org/10.1016/j.geog.2021.05.002>
16. Hamdi, S., & Sumaryati, S. (2020). Pola Lama Penyinaran Matahari dalam 20 Tahun Pengamatan Sumedang. *Jurnal Sains Dirgantara*, 17(2), 81–94. <https://doi.org/http://dx.doi.org/10.30536/j.jsd.2020.v17.a3111>
17. Kouassi, J.-L., Gyau, A., Diby, L., Bene, Y., & Kouamé, C. (2021). Assessing Land Use and Land Cover Change and Farmers' Perceptions of Deforestation and Land Degradation in South-West Côte d'Ivoire, West Africa. *Land*, 10(4), 429. <https://doi.org/10.3390/land10040429>
18. Kum, G. (2016). The influence of dams on surrounding climate: The case of keban Dam. *Gaziantep University Journal of Social Sciences*, 15(24218), 193–204. <https://doi.org/10.21547/jss.256734>
19. Kumar, B. P., Babu, K. R., Anusha, B. N., & Rajasekhar, M. (2022). Geo-environmental monitoring and assessment of land degradation and desertification in the semi-arid regions using Landsat 8 OLI / TIRS, LST, and NDVI approach. *Environmental Challenges*, 8, 100578. <https://doi.org/10.1016/j.envc.2022.100578>
20. Lykins, K. (2011). *Giving a large dam may affect climate, study finds*. Colorado Arts & Sciences Magazine Archive. <https://www.colorado.edu/asmagazine-archive/node/635>
21. Njoku, E. A., & Tenenbaum, D. E. (2022). Quantitative assessment of the relationship between land use/land cover (LULC), topographic elevation, and land surface temperature (LST) in Ilorin, Nigeria. *Remote Sensing Applications: Society and Environment*, 27, 100780. <https://doi.org/10.1016/j.rsase.2022.100780>
22. Park, S., Tuller, S. E., & Jo, M. (2014). Application of Universal Thermal Climate Index (UTCI) for microclimatic analysis in urban thermal environments. *Landscape and Urban Planning*, 125, 146–155. <https://doi.org/10.1016/j.landurbplan.2014.02.014>

23. Read, J. M., & Torrado, M. (2009). Remote sensing. In *International Encyclopedia of Human Geography* (pp. 335–346). Elsevier. <http://dx.doi.org/10.1016/b978-008044910-4.00508-3>
24. Roy, B., & Bari, E. (2022). Examining the relationship between land surface temperature and landscape features using spectral indices with Google Earth Engine. *Heliyon*, 8(9), e10668. <https://doi.org/10.1016/j.heliyon.2022.e10668>
25. Sahani, N. (2021). Assessment of spatio-temporal changes of land surface temperature (LST) in Kanchenjunga Biosphere Reserve (KBR), India, using Landsat satellite image and single channel algorithm. *Remote Sensing Applications: Society and Environment*, 24, 100659. <https://doi.org/10.1016/j.rsase.2021.100659>
26. Shidiq, I. P. A., Ismail, M. H., Supriatna, S., & Wibowo, A. (2020). Spatial-temporal analysis of changes in land cover and land surface temperature (LST) within Universiti Putra Malaysia campus area. *IOP Conference Series: Earth and Environmental Science*, 561(1), 012031. <https://doi.org/10.1088/1755-1315/561/1/012031>
27. Simangunsong, F., & Kurnia, N. I. (2018). Social Impact Management Ahead Jatigede Dam Construction in Sumedang Regency, Indonesia. *International Journal of Science and Engineering Investigations*, 7(80).
28. Srivanit, M., & Hokao, K. (2013). Evaluating the cooling effects of greening for improving the outdoor thermal Environment at an institutional campus in the summer. *Building and Environment*, 66, 158–172. <https://doi.org/10.1016/j.buildenv.2013.04.012>
29. Stewart, I. D., Oke, T. R., & Krayenhoff, E. S. (2014). Evaluation of the 'local climate zone'scheme using temperature observations and model simulations. *International journal of climatology*, 34(4), 1062–1080.
30. Thenkabail, P. S., Schull, M., & Turrall, H. (2005). Ganges and Indus river basin land use/land cover (LULC) and irrigated area mapping using continuous streams of MODIS data. *Remote Sensing of Environment*, 95(3), 317–341. <https://doi.org/10.1016/j.rse.2004.12.018>
31. Tran, D. X., Pla, F., Latorre-Carmona, P., Myint, S. W., Caetano, M., & Kieu, H. V. (2017). Characterizing the relationship between land use land cover change, and land surface temperature. *ISPRS Journal of Photogrammetry and Remote Sensing*, 124, 119–132. <https://doi.org/10.1016/j.isprsjprs.2017.01.001>
32. Weng, Q., Lu, D., & Schubring, J. (2004). Estimation of land surface temperature–vegetation abundance relationship for urban heat island studies. *Remote sensing of Environment*, 89(4), 467–483.
33. Wong, N. H., & Yu, C. (2005). Study of green areas and urban heat island in a tropical city. *Habitat International*, 29(3), 547–558. <https://doi.org/10.1016/j.habitatint.2004.04.008>
34. Wibowo, A., Kuswantoro, Ardiansyah, Rustanto, A., & Shidiq, I. P. A. (2016). Spatial, temporal analysis of urban heat hazard in Tangerang City. *IOP Conference Series: Earth and Environmental Science*, 47, 012039. <https://doi.org/10.1088/1755-1315/47/1/012039>

35. Wibowo, A., & Salleh, K. O. (2018). Landscape features and potential heat hazard threat: Aspatial-temporal analysis of two urban universities. *Natural Hazards*, 92(3), 1267–1286.
<https://doi.org/10.1007/s11069-018-3363-3>
36. Zare, S., Hasheminejad, N., Shirvan, H. E., Hemmatjo, R., Sarebanzadeh, K., & Ahmadi, S. (2018). Comparing Universal Thermal Climate Index (UTCI) with selected thermal indices/environmental parameters during 12 months of the year. *Weather and Climate Extremes*, 19, 49–57.
<https://doi.org/10.1016/j.wace.2018.01.004>
37. Zhang, Y., Jiang, T., Sun, J., Fu, Z., & Yu, Y. (2022). Sustainable development of urbanization: From the perspective of social security and social attitude for migration. *Sustainability*, 14(17), 10777.
<https://doi.org/10.3390/su141710777>

Figures

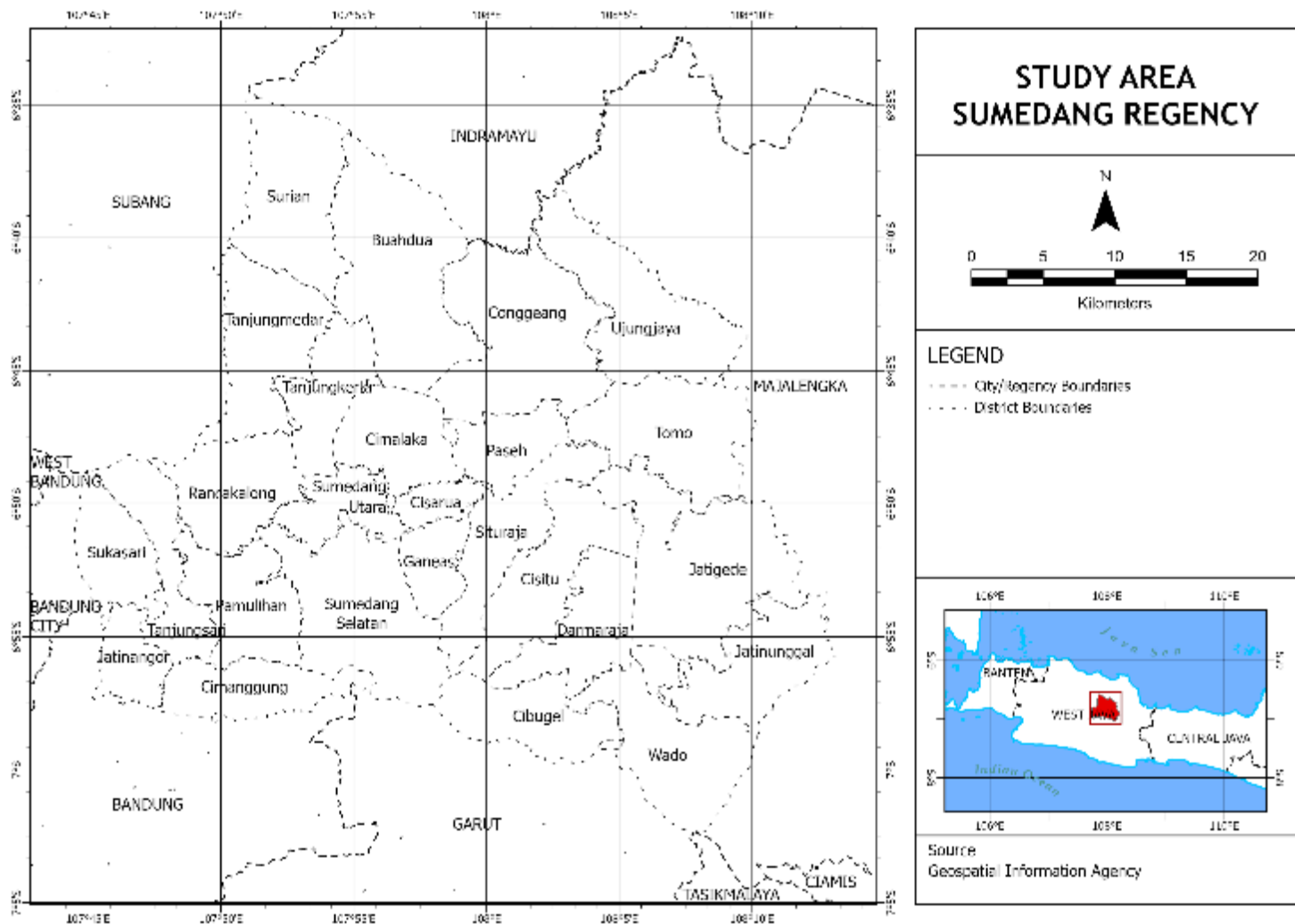


Figure 1

Study Area on Sumedang Regency

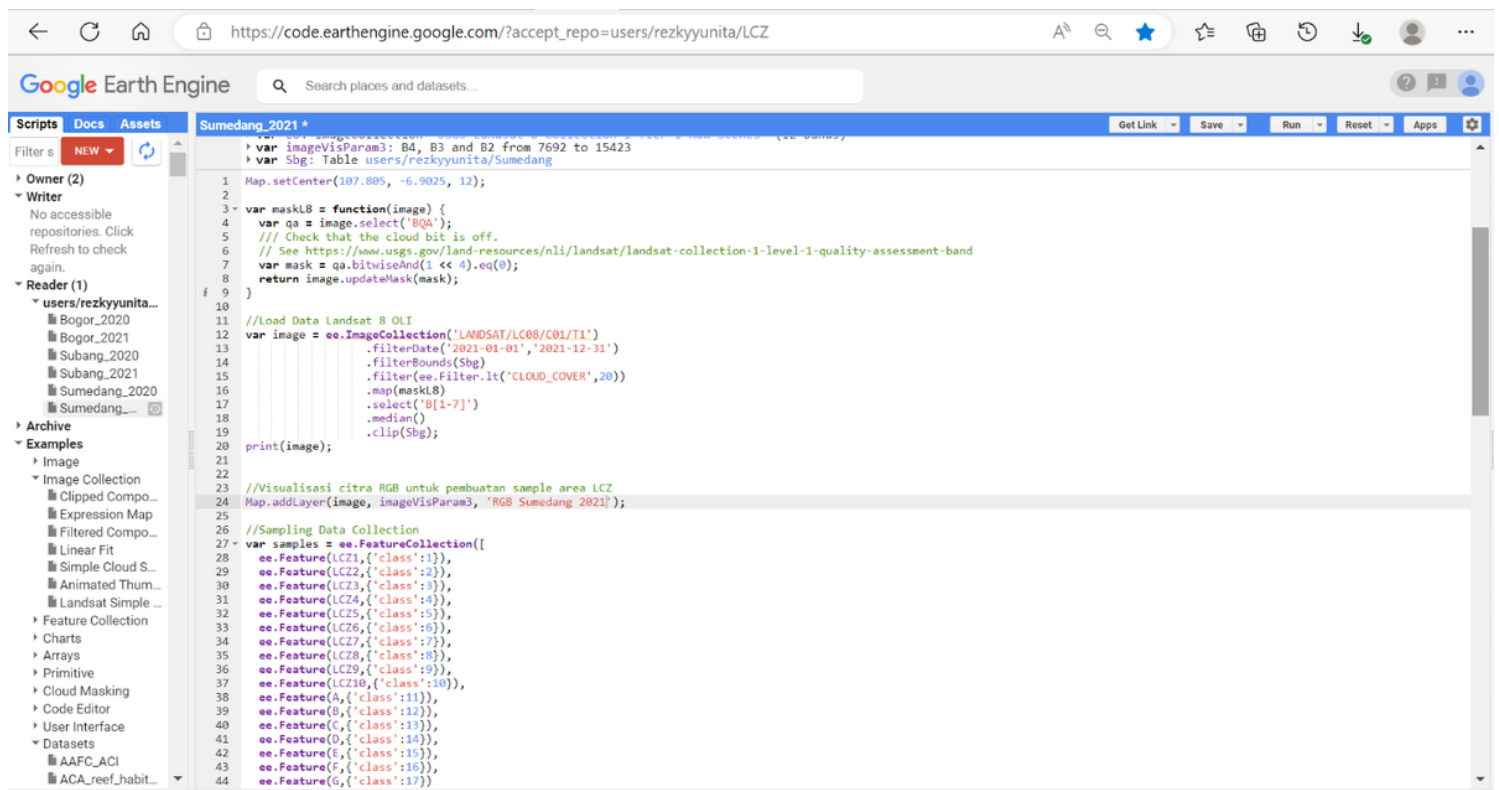


Figure 2

GEE for LCZ Sumedang Regency

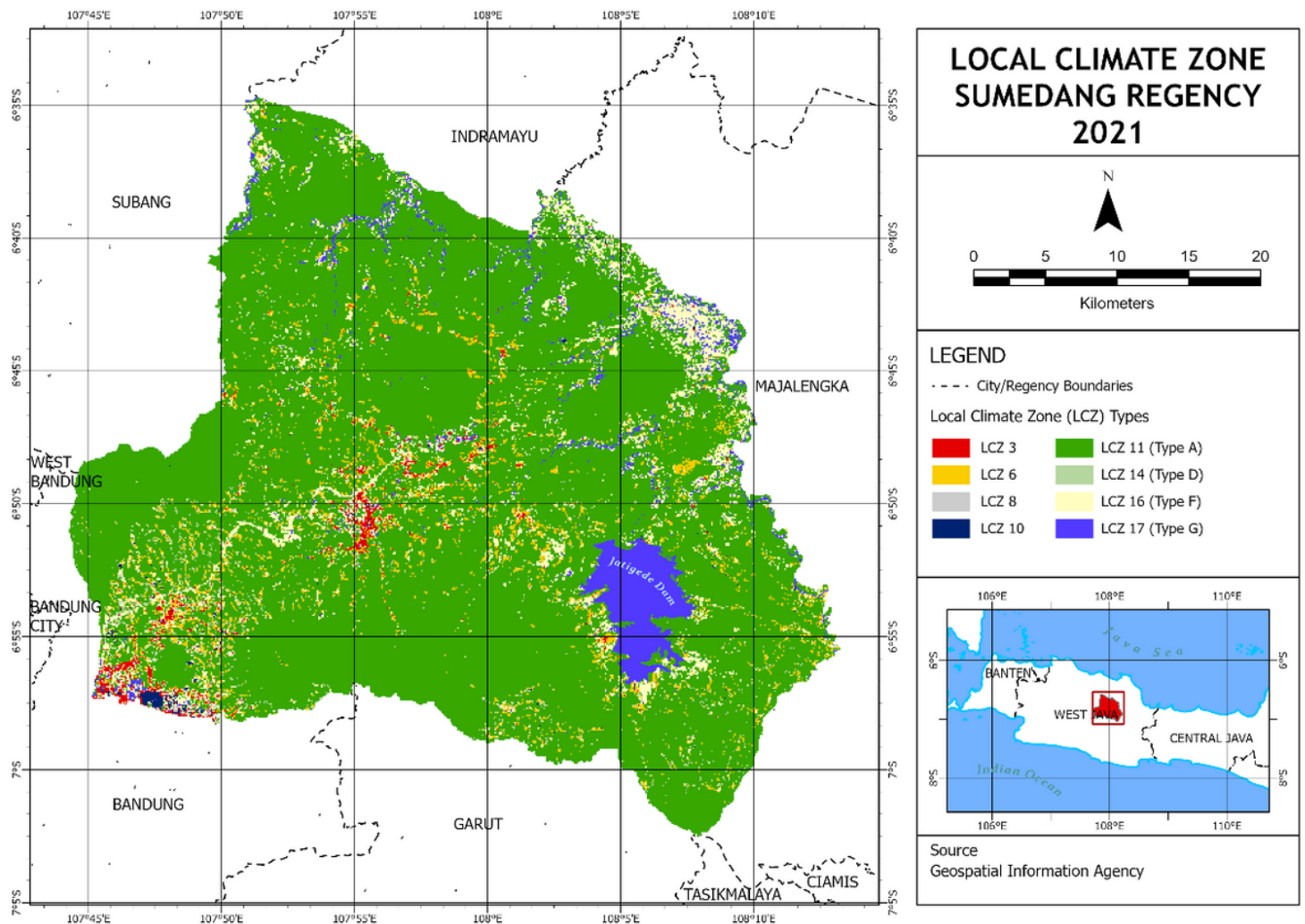


Figure 3

Local Climate Zone in Sumedang Regency

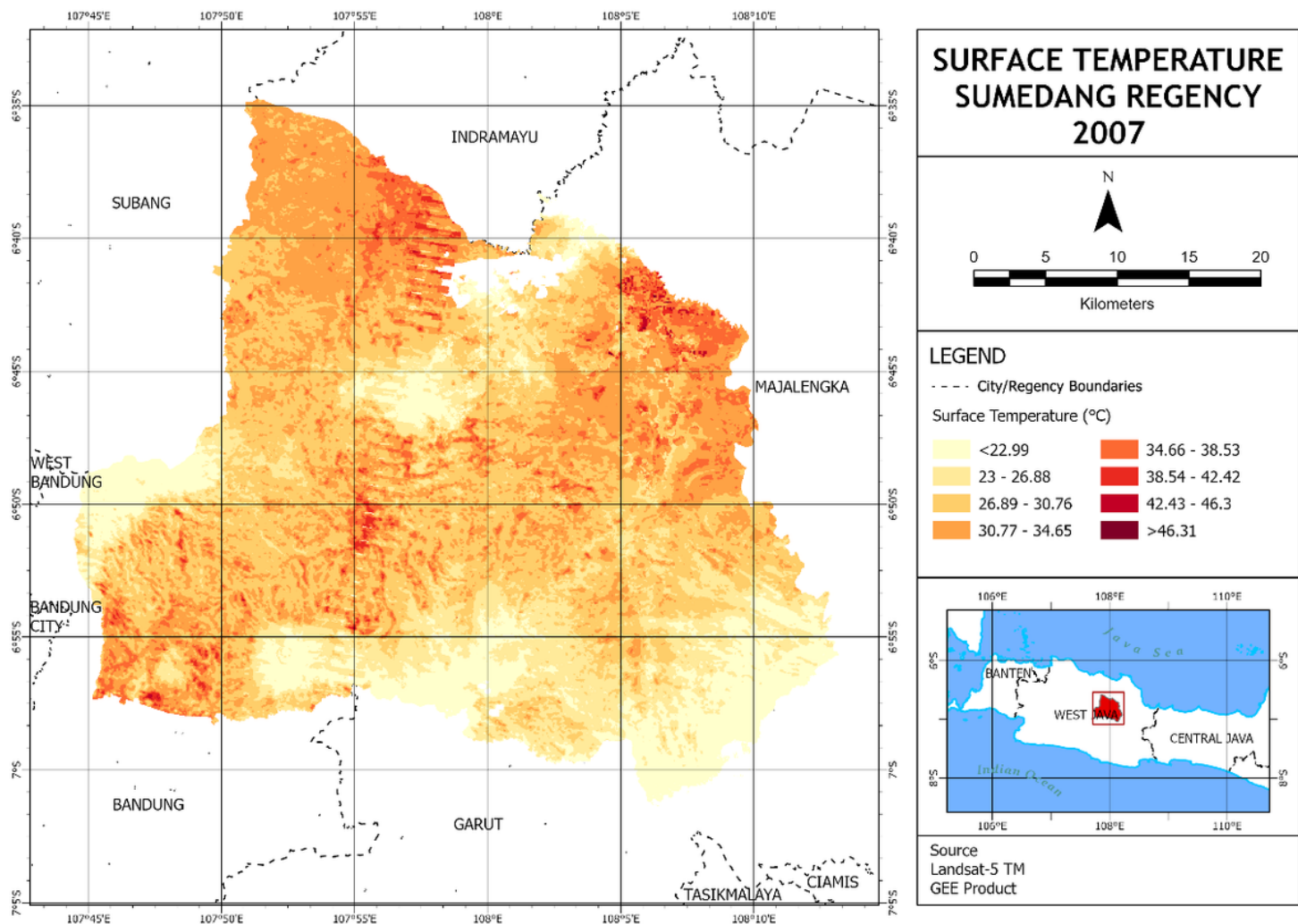


Figure 4

Distribution of land surface temperature 2007 in Sumedang Regency

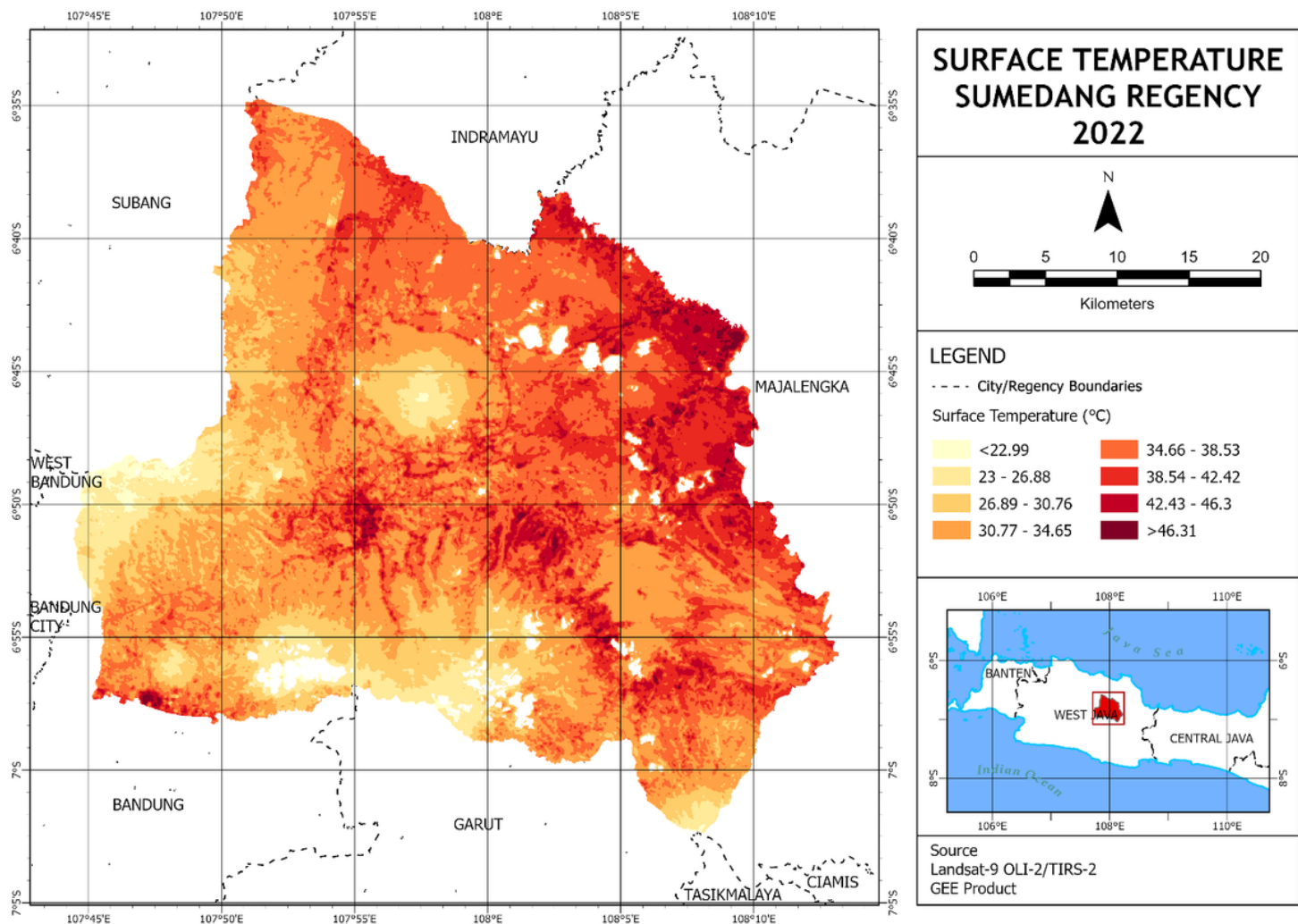


Figure 5

Distribution of land surface temperature 2022 in Sumedang Regency

Avarage LST of 2007-2022

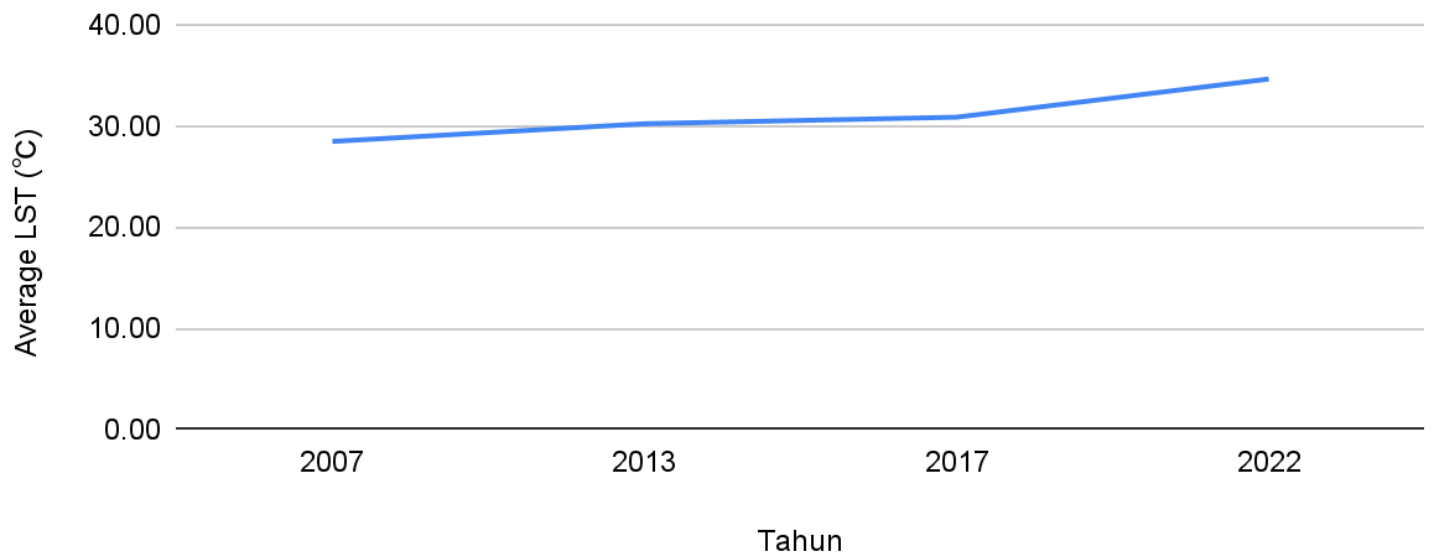
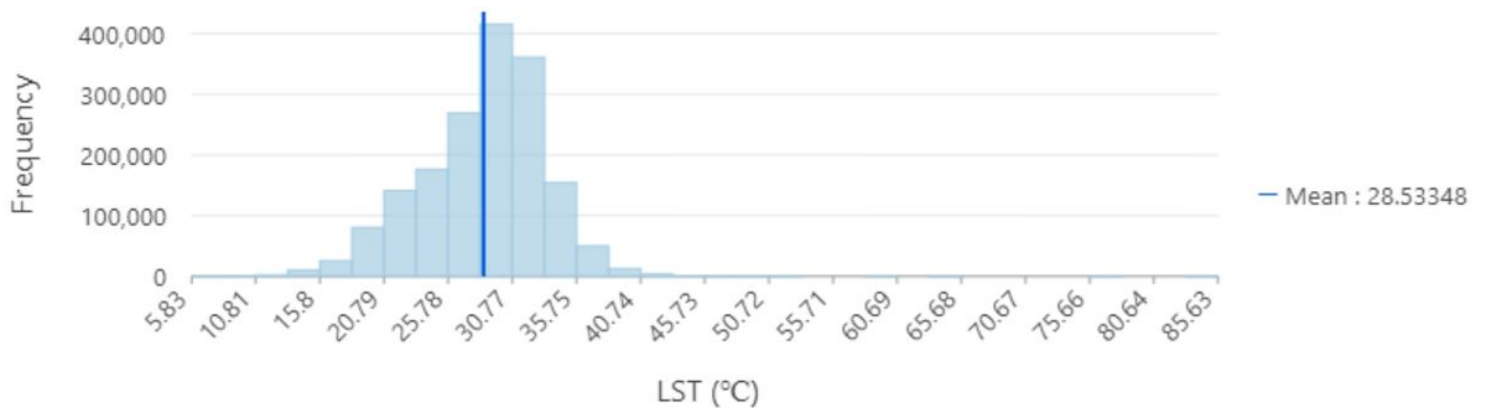


Figure 6

Change in average land surface temperature

Distribution of LST in 2007



Distribution of LST in 2022

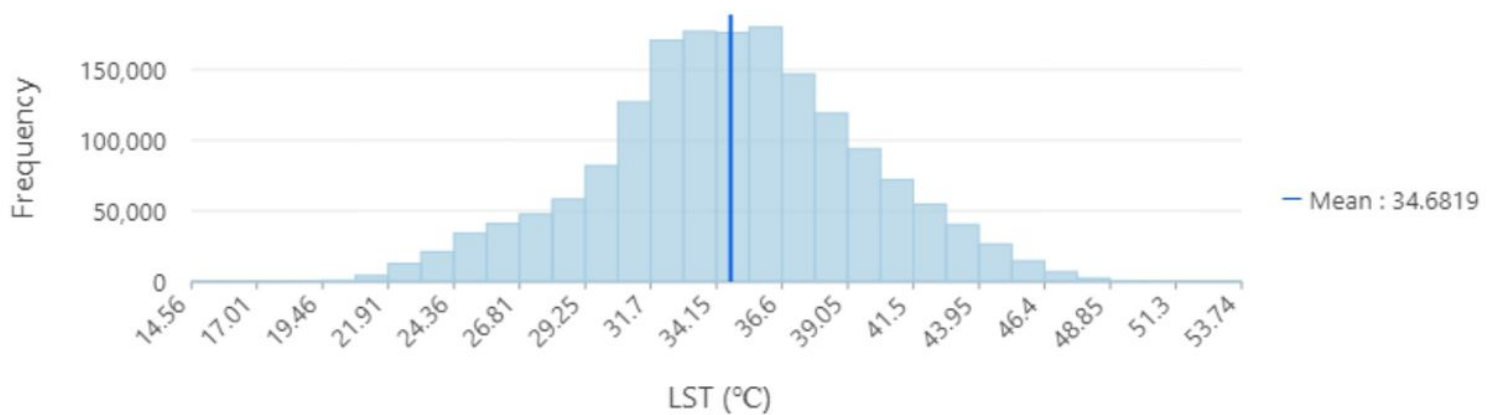


Figure 7

Data distribution of land surface temperature

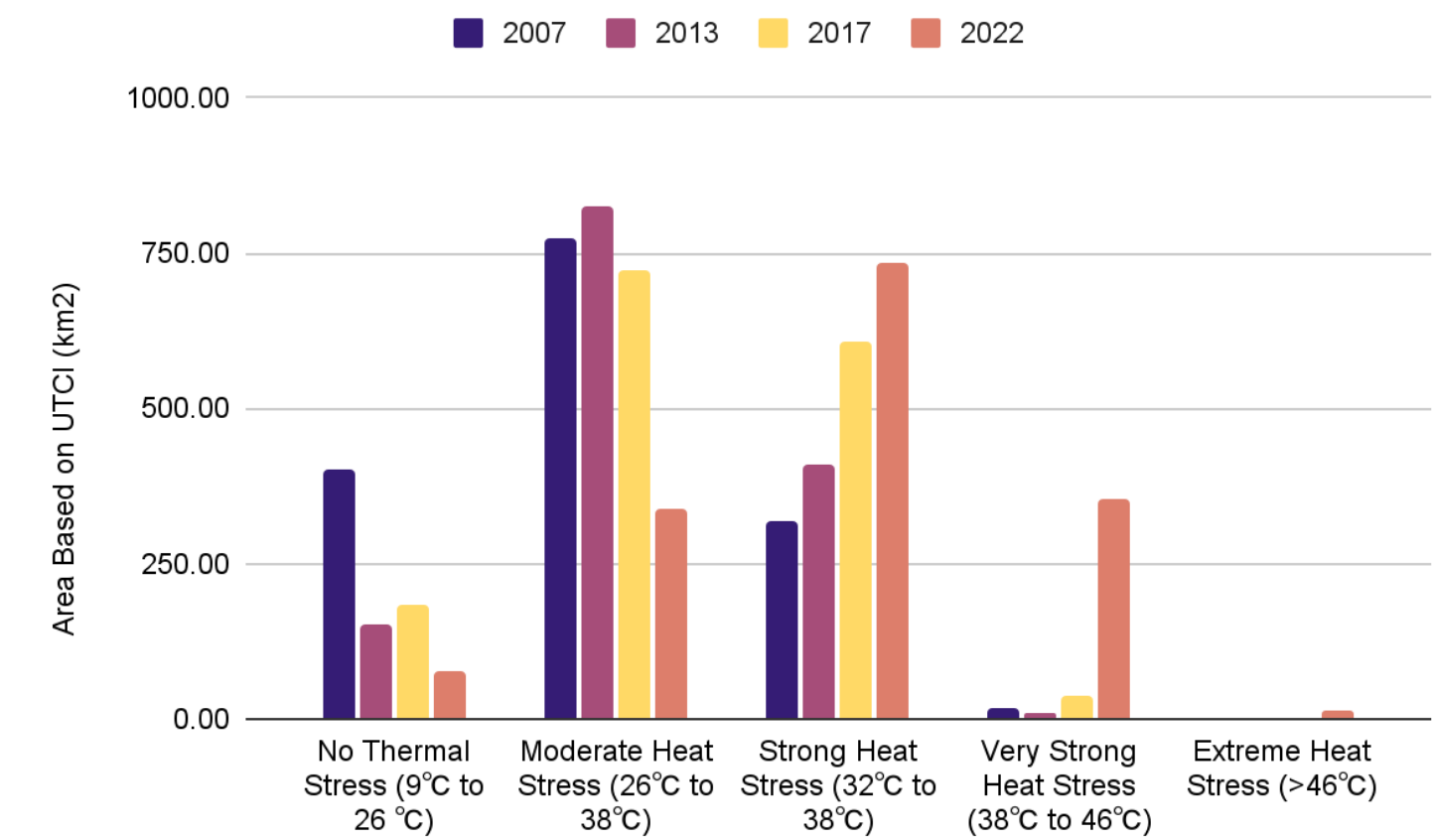


Figure 8

Variation of land surface temperature area based on UTCI

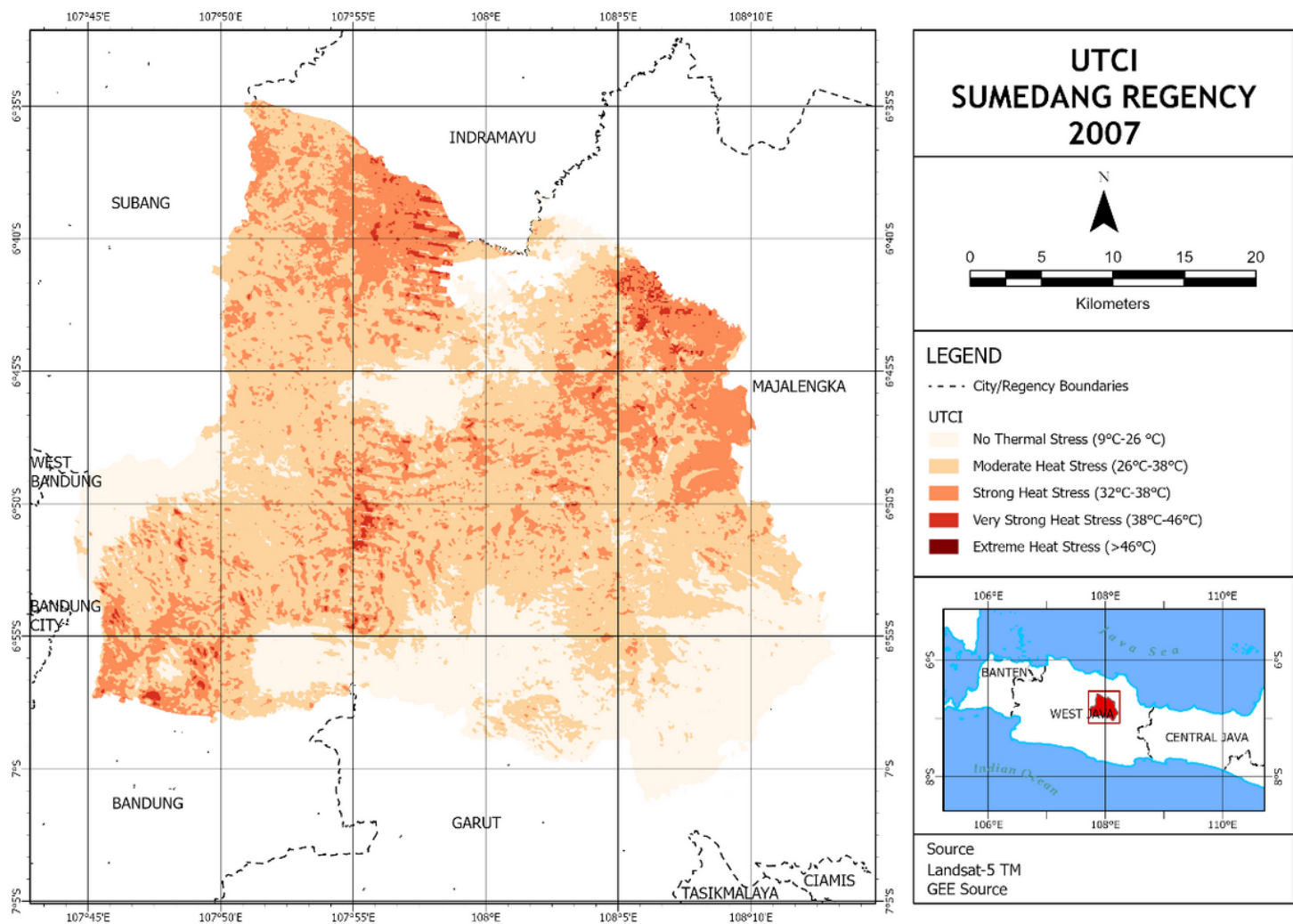


Figure 9

The distribution of UTCI classification 2007

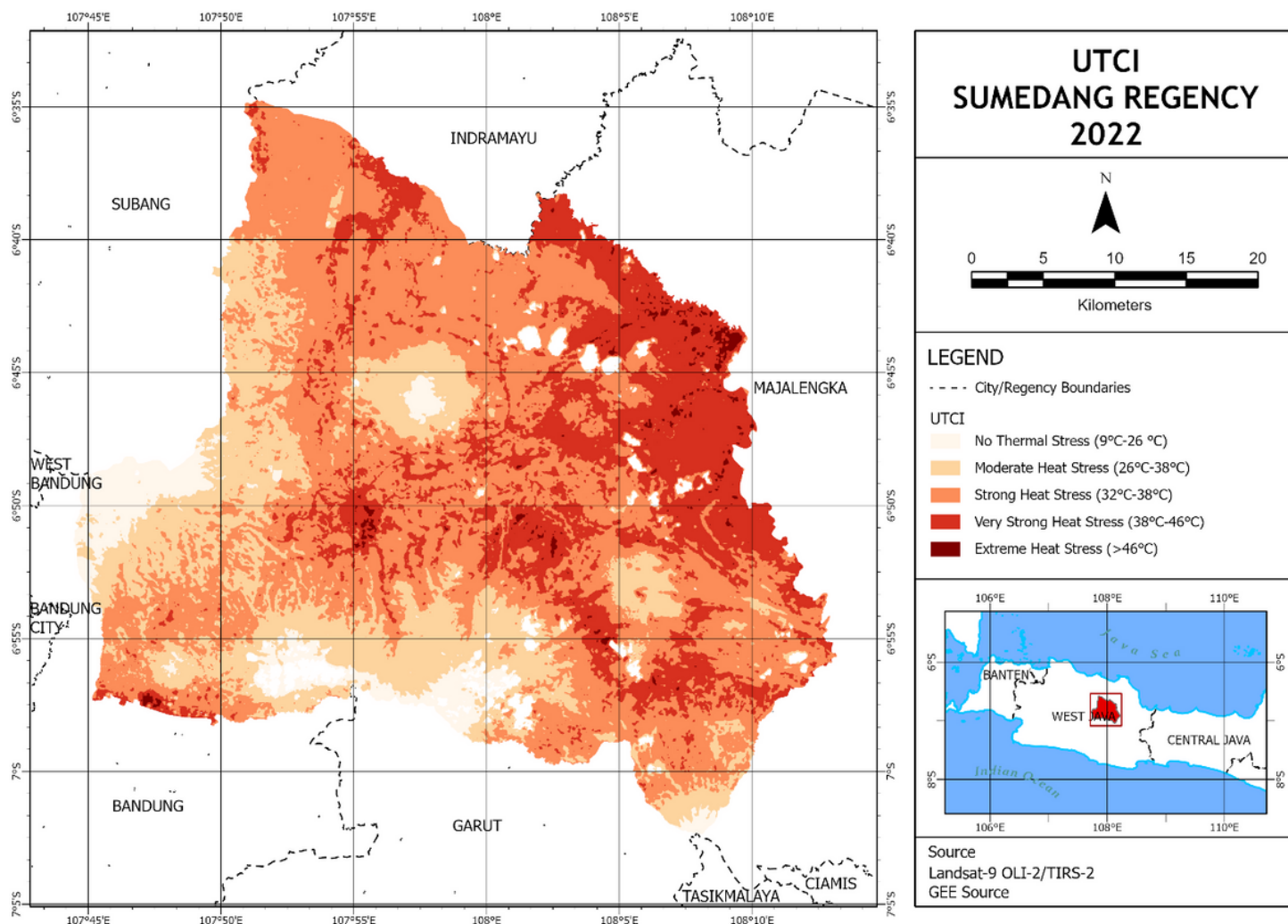


Figure 10

The distribution of UTCI classification 2022