Jurnal Geografi Gea

Journal homepage: https://ejournal.upi.edu/index.php/gea

Analysis of The Capital City of The Archipelago (IKN) in The Perspective of The Future Climate for The Period 2023-2050 using The Data of The SSP 2.0-4.5

Aqash Raechan Anam[1], Bella Puspita Dewi[2], Fahmi Yuwan Purnama[3]

[123]Sekolah Tinggi Meteorologi Klimatologi dan Geofisika, Tangerang Selatan

Correspondence: E-mail: [3]fahmi.yuwan.purnama@stmkg.ac.id

A B S T R A C T

The Archipelago's Capital City Region (IKN) is a candidate for Indonesia's new capital city. It requires in-depth research across all relevant sectors to ensure the comfort of the people of Indonesia. Numerous studies have been conducted in various fields, including social, cultural, political, economic, and others. However, no study has provided a climate-based perspective on IKN compared to the others. Extreme climate indices calculation for the IKN region used the latest projection data, SSP, and statistical analysis techniques via R programming. According to 18 extreme climate indices, the IKN region is expected to experience an increasing trend in both temperature and precipitation indices until 2050. The temperature index that experienced the most significant increase is T90p, while the rainfall index is RX1day. In the IKN region, there is a difference of about 300 days between wet days (CWD) and dry days (CDD), with 350 days being wet and 35 days being dry. Spatial projection analysis has revealed an increase in CWD values in most of the IKN area during the rainy season and a decrease in CWD values during the dry season.

A R T I C L E I N F O

Article History:
Submitted/Received: 12 September 2023
First Revised: 13 Desember 2023
Accepted: 12 February 2024
First Available online: 30 April 2024
Publication Date: 30 April 2024

Keyword:
Climate Projection,
IKN,
SSP

© 2024, FPIPS UPI. Open access article under the CC BY-SA license.

1. INTRODUCTION

Climate change is usually attributed to global warming and is an inevitable aspect of human life (Nurhayati, et al., 2020 ; Tuejeh, et al., 2023) This phenomenon affects human activities across all facets of life, including transportation, agriculture, healthcare, economy, socio-culture, and even democracy (Perdinan et al., 2020 ; Surmaini et al., 2016). Climate change causes severe changes in weather and climate (Hidayat et al., 2018 ; Sulistiyono et al., 2020 ; Suwarman et al., 2022).

The newest IPCC report emphasizes that inadequate adaptation and mitigation efforts could have severe consequences on human life and natural ecosystems due to climate change impacts (Suryadi et al., 2017 ; Tulak et al., 2022). Scientists predict that the earth's temperature will increase by 3°C by the end of this century, if the current emissions do not decrease (Pörtner et al., 2022). Moreover, both adaptation and mitigation of climate change are necessary to be carried out in a balanced and comprehensive manner (Abbasi et al., 2020).

Several methods are used to describe future climate conditions, and one such method is to use climate change scenarios, also known as climate projections (Suryadi et al., 2017 ; Akinnusotu, et al., 2023 ; Saringatin, 2022). The most recent climate projection is known as the Coupled Model Intercomparison Project6 (CMIP6), which is based on full-strength mitigation with sustainable emissions and is the most complex projection created to date (Gusain et al., 2020; Ridwana et al., 2023). There are multiple CMIP6 assumptions, including the Shared Socioeconomic Pathways 2 (SSP2), which emphasizes moderate mitigation and adaptation across social, economic, technological, and developmental factors (Eyring et al., 2016). Compared to previous climate projections, the use of CMIP6 is purportedly more realistic in describing climate variables (Zhu et al., 2020).

Given the development plan of the Capital City of the Archipelago (IKN), situated in the East Kalimantan region between the Penajam Paser Utara (PPU) Regency and Kutai Kartanegara Regency, it is necessary to envision future climate scenarios. In IKN, the annual rainfall intensity is classified as very high, reaching 2,223 millimeters per year (Marzuki, 2023). Since 1983, temperature conditions in IKN have significantly increased. Moreover, there are few studies concerning weather and climate in the IKN region. Therefore, the purpose of this study is to investigate changes in temperature and precipitation variables, as well as their relationship to potential future climate change using climate projections in the IKN region.

2. METHODS

The research area selected for this study is the Capital City of the Archipelago (IKN) area, located between 117° 0' 31.292" and 117° 11' 51.903" East longitude and 0° 38' 44.912" and 1° 15' 25.260" South latitude. The area covers the North Penajam Paser Regency and Kutai Kartanegara Regency in the East Kalimantan Province. The boundaries of the area are defined by the following coordinates:

- North: 1° 15' 25.260" S, longitude 117° 0' 31.292" E
- East: 1° 6' 42.398" S, longitude 117° 18' 28.084" E
- West: 0° 59' 22.510" S, longitude 116° 31' 37.728" E

To be precise, the IKN area is partly located in North Penajam Paser Regency and partly in Kutai Kartanegara Regency within East Kalimantan Province.

DOI: https://doi.org/10.17509/gea.v24i1.62607
p- ISSN 1412-0313 e- ISSN 2549-7529

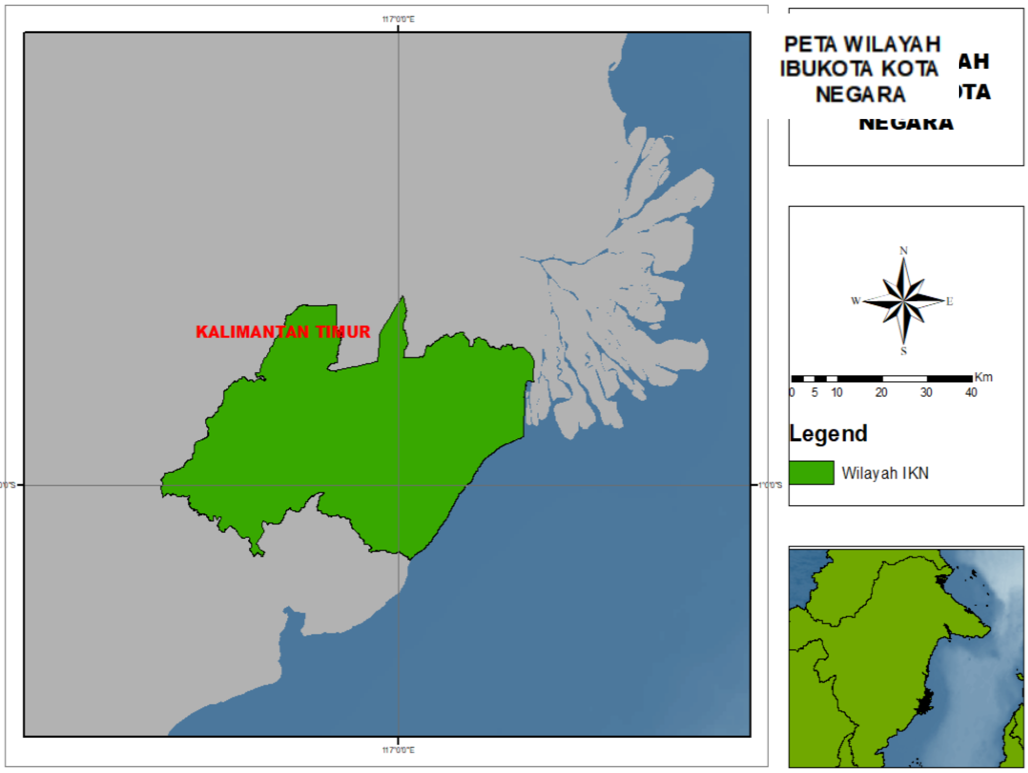

Figure 1. Research Maps

This study used the CMIP6 climate projection data from the latest SSP2 scenario of the MRI-ESM 2-0 model. The SSP2 data period used in this study is from 2015 to 2050, with a baseline of 2015 to 2020. The projection data was corrected prior to use. Rainfall and temperature are the variables of interest, calculated using the climate indices formula established by the Expert Team for Climate Change Detection Monitoring and Indices (ETCCDMI). Data processing is performed using the R programming software package RClimdex. RClimdex is an R package that directly processes and calculates the extreme climate indices. The methods employed include the average method, linear regression, and Mann-Kendall trend test. 18 extreme climate indices were selected and are presented below.

Tabel 1. Extreme Climate Index Indicators

Index	Indicator Name	Definition	Unit
TN10p	Cool nights	Percentage of days with minimum temperature < 10th percentile	%
TN90p	Warm nights	Percentage of days with minimum temperature > 90th percentile	%
TX10p	Cool days	Percentage of days with maximum temperature < 10th percentile	%
TX90p	Warm days	Percentage of days with maximum temperature > 90th percentile	%
TNn	Min Tmin	Monthly minimum value of minimum temperature	ºC
TNx	Max Tmin	Monthly maximum value of minimum temperature	ºC
TXn	Min Tmax	Monthly minimum value of maximum temperature	ºC
TXx	Max Tmax	Monthly maximum value of maximum temperature	ºC

DOI: https://doi.org/10.17509/gea.v24i1.62607
p- ISSN 1412-0313 e- ISSN 2549-7529

SDII	Simple Daily Intensity Index	Total amount of rainfall for 1 year divided by rainy days	mm
RX1day	Max-1 day precipitation amount	Highest daily rainfall amount in one month	mm
RX5day	Max-5 day precipitation amount	Most amount of rainfall for 5 consecutive days	mm
CDD	Consecutive Dry Days	Most number of days when rainfall <1mm	Day
CWD	Consecutive Wet Days	Most number of days when rainfall > 1mm	Day
R95p	Very Wet Days	Total annual rainfall amount When rainfall > 95th percentile	mm
R20mm	Annual count of days when PRCP ≥ 20mm	Number of days when daily rainfall is 20 mm	Day
R25mm	Annual count of days when PRCP ≥ 25mm	Number of days when daily rainfall is 25 mm	Day
PRCPTOT	Annual total wet-day precipitation	Total annual rainfall with rainfall greater than or equal to 1 mm	mm
DTR	Daily Temperature Range	The daily maximum temperature difference with the daily minimum temperature	^{o}C

Source: ETCCDMI (2017)

3. RESULTS AND DISCUSSION

The Results and Discussion section explains each climate variable used in the calculation of the extreme climate index in the IKN region, namely minimum temperature, maximum temperature, precipitation, CDD, and CWD.

1. Minimum Temperature

The minimum temperature index itself consists of the minimum monthly value of the minimum temperature (TNn), the maximum monthly value of the minimum temperature (TNx), the percentage of days with minimum temperatures above the 90th percentile (TN90p), and the monthly mean minimum temperature (TMINmean), which is used to see changes in the patterns that occur in the minimum temperature in the capital of the archipelago (IKN).

Based on Figure 2 below, it can be seen that the average minimum temperature is projected to increase during the period 2023-2050 with a rate of change of 0.023 C/year. The projection results show that the highest average minimum temperature will occur in 2046 with a value of 25.0 C, while the lowest minimum temperature will occur in 2040 with an average value of 22.0 C.

DOI: https://doi.org/10.17509/gea.v24i1.62607
p- ISSN 1412-0313 e- ISSN 2549-7529

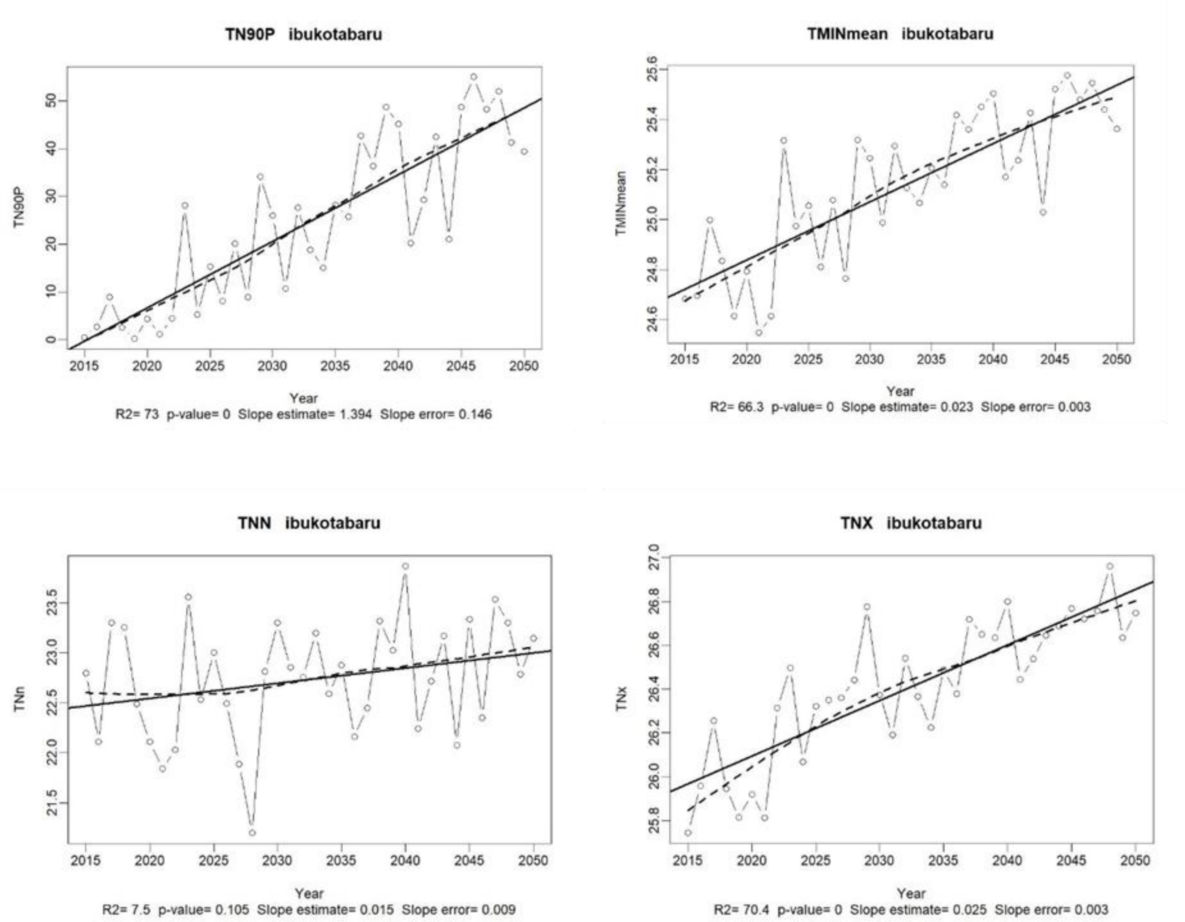

Figure 2. Graphic Minimum Temperature Index

TN90p is projected to increase with a rate of change reaching 1, 394 oC/year in 2023-2050. TN90p is the percentage of days where the minimum temperature reaches the 90th percentile, defined as cool nights. The highest percentage of days in a year with extreme minimum temperatures at the 90th percentile is projected to occur in 2046, reaching 53% of occurrences in a year.

Figure 2 also displays a graph representing the index for the smallest value of minimum temperature (TNn) and the largest value of minimum temperature (TNx). TNn and TNx are referred to as the coldest night and the warmest night temperatures, respectively, by You et al. (2010). During the period from 2023 to 2050, the projected TNn exhibits an increasing trend with a change rate of temperature of 0.015 oC. According to the projections, TNn is expected to reach its highest value in 2040, reaching 24.5 C, while the lowest is projected to happen in 2028, at 20.4 C. Additionally, the period between 2023 and 2050 is expected to see an increase in the projected values for TNx, with a rate of change of 0.025 C per year. The projections indicate that the highest TNx value will occur in 2048, reaching 26.9 C, while the lowest value is projected to happen in 2024, at 26.1 C.

2. Maximum Temperature

The Maximum Temperature Index is composed of several variables. First, the percentage of days where maximum temperatures are above the 90th percentile value (TN90p). Second, the largest monthly value of maximum temperature (TXx). Third, the smallest monthly value of maximum temperature (TXn). Fourth, the monthly average maximum temperature (TMAXmean) used to observe any changes in temperature patterns. Finally, the daily temperature difference (DTR) is used to measure the difference between the maximum temperature and daily minimum temperature. These variables are measured in the Capital City of the Archipelago (IKN).

DOI: https://doi.org/10.17509/gea.v24i1.62607
p- ISSN 1412-0313 e- ISSN 2549-7529

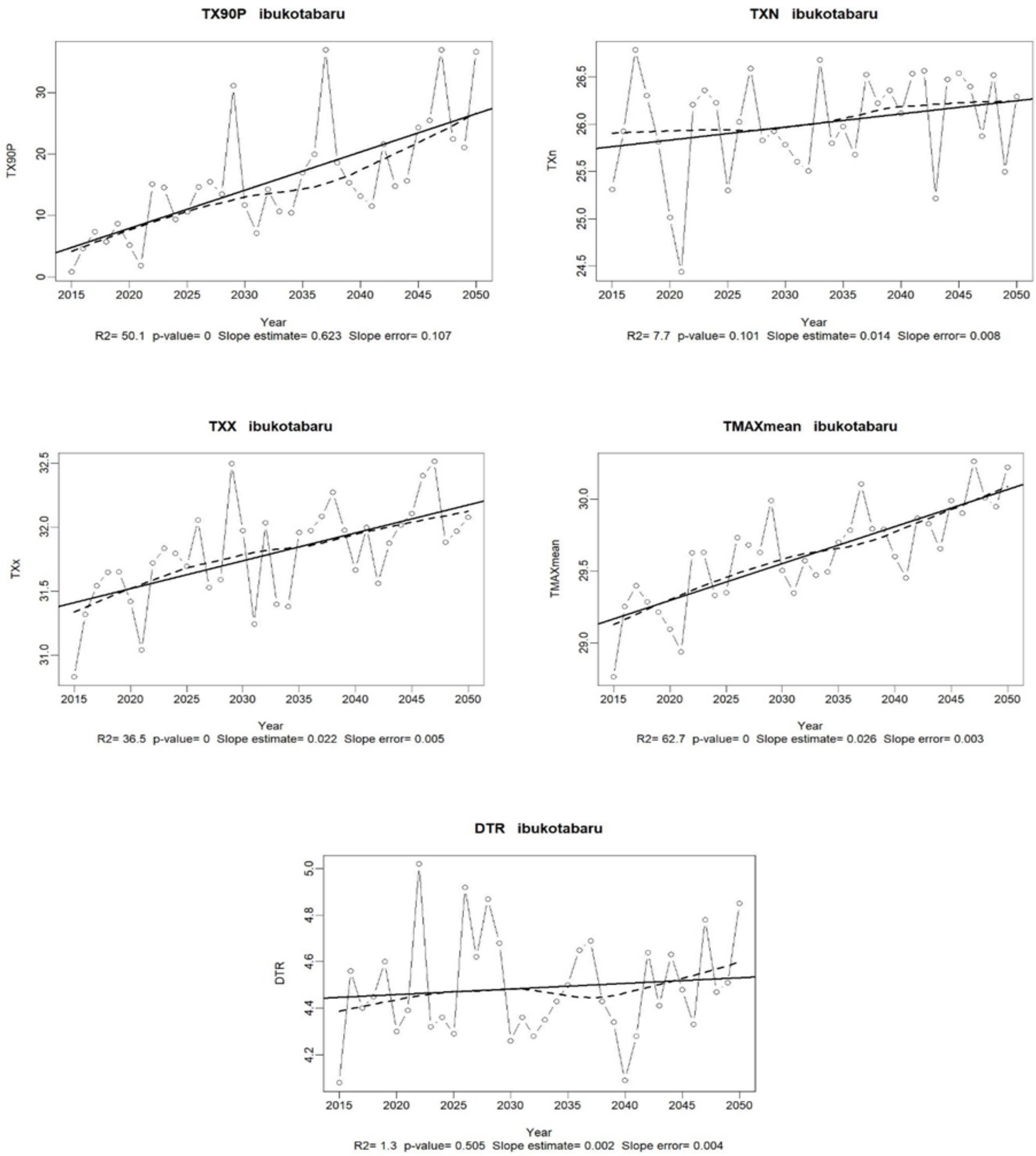

Figure 3. Graphic Maximum Temperature

Figure 3 indicates a projected increase in the average maximum temperature during the period 2023-2050 with a rate of change of 0.014°C/year. According to the projection results, the average maximum temperature will reach its peak in 2023 (30.0°C), and its lowest point in 2043 (25.3°C). The projection shows an increase in TX90p with a rate of change of 0.623°C/year during the period 2023-2050. TX90p refers to the percentage of days when the maximum temperature reaches the 90th percentile, defined as a warm night. According to the projection, 2038 will experience the highest percentage of days in a year with extreme maximum temperatures at the 90th percentile, reaching 37% of the total yearly events.

Figure 3 includes a graph illustrating the index of the minimum value of maximum temperature (TXn) and the maximum value of maximum temperature (TXx). There is an increasing trend in TXn projections for the period of 2023-2050 with a rate of change of 0.014 C. By 2033, the highest TXn

DOI: https://doi.org/10.17509/gea.v24i1.62607
p- ISSN 1412-0313 e- ISSN 2549-7529

is projected to occur at 30.0 C. Conversely, the lowest TXn is expected to occur in 2043, reaching 25.3 C. Additionally, projections for TXx during the period of 2023-2050 depicts an increasing trend with a rate of change of 0.022 C/year. By 2029, the highest TXx is projected to occur at 32.1 C, while the lowest is expected to occur in 2021 at 31.3 C.

3. Rainfall

Extreme rainfall indices such as the maximum total rainfall for 5 days and 1 day (RX5day and RX1day), the total annual rainfall amount when rainfall is >95th percentile (R95p), the number of days when daily rainfall is 20 mm and 25 mm (R20mm and R25mm), the total annual rainfall amount with rainfall more or equal to 1 mm (PRCPTOT).

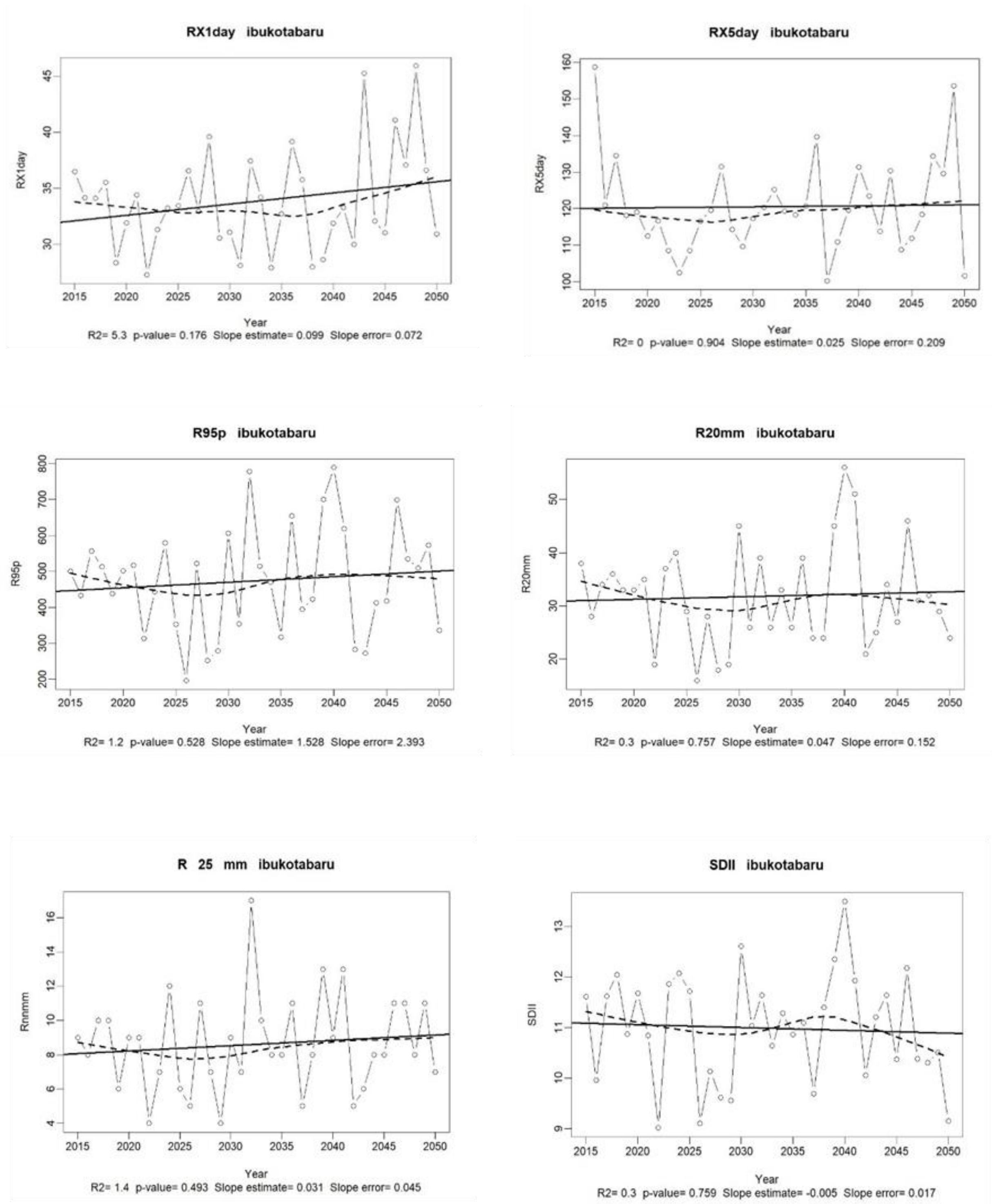

Figure 4. Graphic Rainfall Index

DOI: https://doi.org/10.17509/gea.v24i1.62607
p- ISSN 1412-0313 e- ISSN 2549-7529

The maximum amount of rainfall intensity in one day is expressed by the RX1day index as shown in Figure 3. It can be seen that the projection results for the period 2023-2050, the largest rainfall in one day has an increasing trend with a relatively low slope value of 0.099 mm/day. The highest average rainfall in one day is projected to occur in 2048 with rainfall of 48 mm/day. The RX5day index represents the highest amount of rainfall calculated in five consecutive days. The projection results show that this index has a fixed trend during the period 2023-2050 with a slope of 0.025. The highest average rainfall in five days is projected to occur in 2049 with 150 mm of rainfall in 5 days. Then there is R20mm or the number of days there is light rainfall. It can be seen that in the projection period 2023-2050 the trend tends to remain with a slope value of 0.047. The highest value is in 2040 with 58 days. Furthermore, at R25 mm or the number of days there is moderate rainfall in the projection period 2023-2050 the trend tends to increase with a slope value of 0.031. The highest value is in 2032 with 18 days.

Furthermore, there is R95p, which is the amount of annual rainfall when it is greater than the 95th percentile. In the projection period, the trend tends to increase with a slope value of 1.5238. On the other hand, the SDII value tends to decrease with a slope value of -0.0005.

Rainfall in the IKN region is seen for all climate indices calculated to have dominantly increased but lower than temperature. Moderate rainfall in the IKN region has increased more than low rainfall even though the number of days is less, meaning that a significant increase in rainfall is projected from year to year in the IKN region. When viewed from 5 consecutive days also the highest amount of rainfall in the IKN region is above 150 mm and is considered high.

4. CDD and CWD

Consecutive dry days (CDD) is the number of consecutive days without rain or with rainfall intensity less than 1mm and Consecutive wet days (CWD) is the number of consecutive days with rainfall intensity greater than 1 mm. Extreme climate index Simple daily intensity index (SDII) is the total amount of rainfall for 1 year divided by wet days (defined as rainfall more than 1 mm/day).

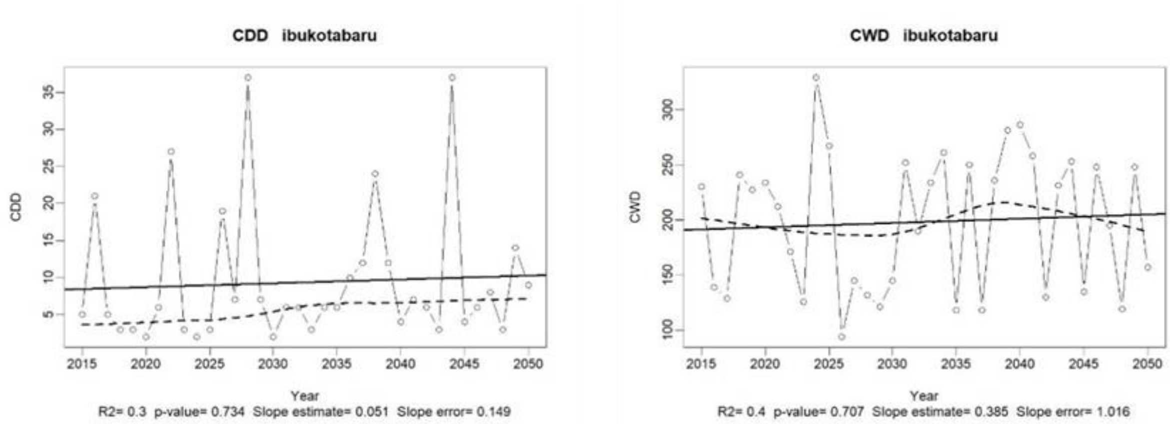

Figure 5. Graphic CDD and CWD Index

In the projection period, it can be seen that the trend of CDD values is relatively fixed and CWD tends to increase with slope values of 0.051 and 0.385, respectively. The highest value of CDD occurred in 2028 with 37 days and the highest value of CWD occurred in 2023 with 340 days. A decrease in the CDD value indicates an increase in the average rainfall of the region which can have an impact on agriculture. There is such a large difference in days between CDD and CWD of almost 250 days, meaning that the IKN region is projected to have more wet days than dry days or it can be said that the amount of rainfall is very high and is also influenced by other climate phenomena (M. Munir, 2009). Spatial mapping is also carried out for the value of CDD and CWD in Kalimantan island where IKN is located.

DOI: https://doi.org/10.17509/gea.v24i1.62607
p- ISSN 1412-0313 e- ISSN 2549-7529

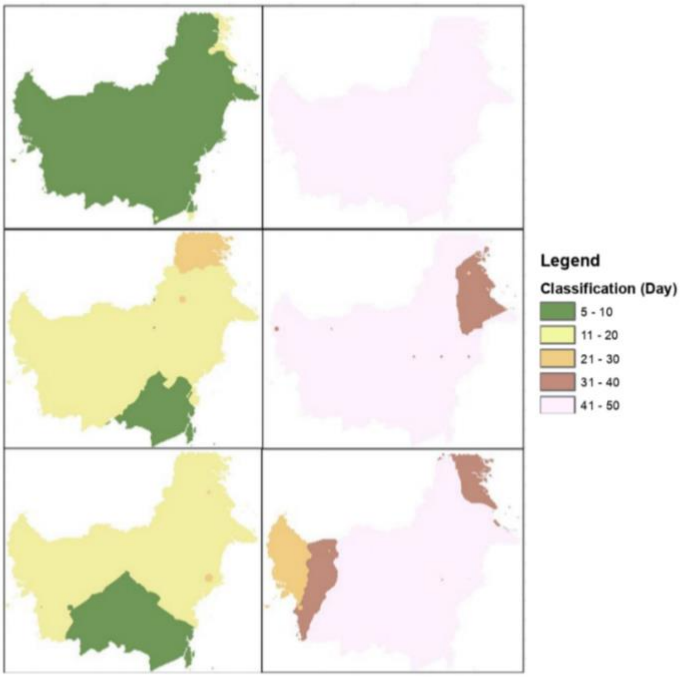

Figure 6. Spatial map of CDD and CWD in the wet season

It can be seen and analyzed for spatial mapping of CDD and CWD in the rainy season which generally occurs in December, January and February. It can be seen that in the IKN region, the CDD value in December is generally 5-10 days of rain. In January and February there is a spatial increase, namely rainy days of 11-20 days. Then for the CWD value in the IKN region in December, January, and February the range of values is the same, namely 41-50 days. It can be said that spatially in the rainy season there is a very large difference between wet days and dry days (Zhang et al., 2011 ; Zarrin et al., 2021 ; Zong et al., 2023 ; Wang et al., 2021).

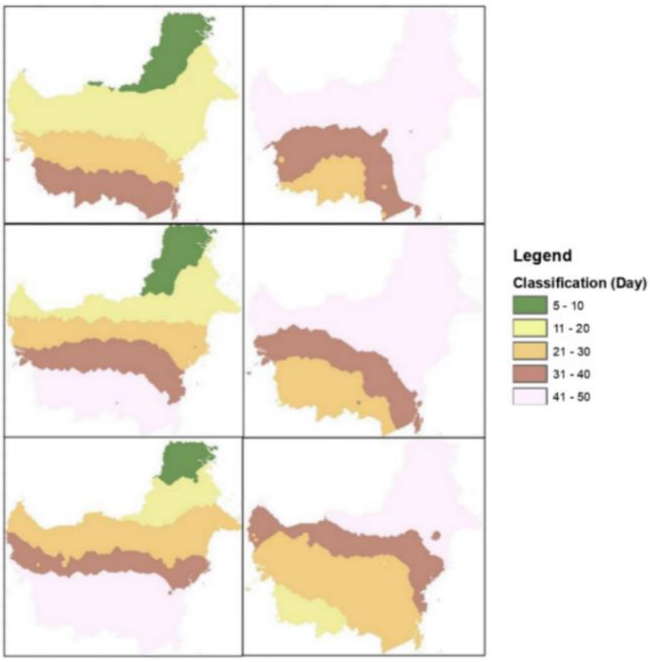

Figure 7. Spatial map of CDD and CWD in the dry season

DOI: https://doi.org/10.17509/gea.v24i1.62607
p- ISSN 1412-0313 e- ISSN 2549-7529

It can be seen and analyzed for spatial mapping of CDD and CWD in the dry season which generally occurs in June, July, and August. It can be seen that in the IKN region, the CDD value in June is generally 11-20 days of rain. In July and August, there was a spatial increase of 21-30 days of rain. Then for the CWD value in the IKN region in June and July amounted to 41-50 days while in August there was a decrease to 31-40 days. It can be said that wet days are higher than dry days despite being in the dry season (Nastos and Zerefos, 2009 ; Shi et al., 2018 ; Jianfeng et al., 2012). In the dry season there is a decrease in wet days and an increase in dry days in the IKN region. Information on projected CDD and CWD values can be key in mitigating climate extremes, namely rainfall.

4. CONCLUSIONS

on 18 extreme climate indices, the IKN region is projected to experience an increasing trend for temperature and rainfall until 2050. The most significantly increasing temperature index is T90p and for the rainfall index is RX1day. Then there is a difference of about 300 days between wet and dry days in the IKN region with 350 wet days and 35 dry days. Spatial projection analysis shows that most of the IKN region in the rainy season has an increase in CWD values and the dry season has a decrease in CWD value.

6. REFERENCES

Abbasi, Z. A. K., dan Nawaz, A. (2020). Impact of climate change awareness on climate change adaptions and climate change adaptation issues. *Pakistan Journal of Agricultural Research*, 33(*3*), 619.

Akinnusotu, A., Abulude, F. O., Adeoya, E. A., Adeyemi, O. O., Jiddah-Kazeem, S. B., Arifalo, K. M., ... & Sunday, A. (2023). Jurnal Geografi Gea. *Jurnal Geografi Gea*, 23(*2*), 91-106.

Eyring, V., Bony, S., Meehl, G. A., Senior, C. A., Stevens, B., Stouffer, R. J., & Taylor, K. E. (2016). Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization. *Geoscientific Model Development*, 9(*5*), 1937-1958.

Gusain, A., Ghosh, S., & Karmakar, S. (2020). Added value of CMIP6 over CMIP5 models in simulating Indian summer monsoon rainfall. *Atmospheric Research*, 232, 104680.

Hidayat, N. M., Pandiangan, A. E., & Pratiwi, A. (2018). Identifikasi perubahan curah hujan dan suhu udara menggunakan Rclimdex Di wilayah Serang. *Jurnal Meteorologi Klimatologi dan Geofisika*, 5(*2*), 37-44.

Jianfeng, L., Qiang, Z., & Yungang, B. (2012). Spatio-temporal Probability Behaviors of the Maximum Consecutive Wet Days in Xinjiang, China. *Acta Geographica Sinica*, 66(*3*), 312-320.

M. Munir. (2009). Studi respon curah hujan di kalimantan selatan terhadap indeks osilasi Selatan. *Buletin Meteorologi dan Geofisika*, 6 (*1999*).

Marzuki, M., Ramadhan, R., Yusnaini, H., Vonnisa, M., Safitri, R., & Yanfatriani, E. (2023). Changes in Extreme Rainfall in New Capital of Indonesia (IKN) Based on 20 Years of GPM-IMERG Data. *Trends in Sciences*, 20(*11*), 6935-6935.

Nastos, P. T., & Zerefos, C. S. (2009). Spatial and temporal variability of consecutive dry and wet days in Greece. *Atmospheric Research,* 94(*4*), 616-628.

DOI: https://doi.org/10.17509/gea.v24i1.62607
p- ISSN 1412-0313 e- ISSN 2549-7529

Nurhayati, D., Dhokhikah, Y., & Mandala, M. (2020). Persepsi dan strategi adaptasi masyarakat terhadap perubahan iklim di kawasan Asia Tenggara. *Jurnal Proteksi: Jurnal Lingkungan Berkelanjutan*, 1(*1*), 39-44.

Perdinan, P. (2014). Perubahan iklim dan demokrasi: Ketersediaan dan akses informasi iklim, peranan pemerintah, dan partisipasi masyarakat dalam mendukung implementasi adaptasi perubahan iklim di Indonesia. *Jurnal Hukum Lingkungan Indonesia*, 1(*1*), 109-132.

Pörtner, H., Roberts, D., Poloczanska, E., Mitenbeck, K., Tignor, M., & Alegria, A. (2022). IPCC Sixth Assessment Report in Cambridge University Press.

Ridwana, R., Himayah, S., Rabbi, M. F. A., Lugina, I. M. A., Al Kautsar, A., & Sakti, A. D. (2023). Monitoring Aerosol Optical Depth for Air Quality Through Himawari-8 in Urban Area West Java Province Indonesia. *Jurnal Geografi*, 15(*2*), 182-194.

Saringatin, S., Ramadan, G. F., Widiastuti, E. I., & Arjasakusuma, S. (2022). Analysis of Urban Comfort Level in Java Island Based on Air Temperature and Air Quality in 2015–2019. *Jurnal Geografi Gea,* 22(*1*), 77-86.

Shi, J., Cui, L., Wen, K., Tian, Z., Wei, P., & Zhang, B. (2018). Trends in the consecutive days of temperature and precipitation extremes in China during 1961–2015. *Environmental research*, 161, 381-391.

Sulistiyono, W., Adianova, H., & Haryanto, Y. D. (2023). Verifikasi Data Suhu Udara Luaran Model Iklim CMIP5 Terhadap Data Observasi Pada Wilayah Palembang (Periode 1975-2005). Optika: *Jurnal Pendidikan Fisika*, 7(*1*), 146-154.

Surmaini, E., dan Faqih, A. (2016). Kejadian iklim ekstrem dan dampaknya terhadap pertanian tanaman pangan di Indonesia.

Suryadi, Y., Sugianto, D. N., & Hadiyanto, H. (2017). Identifikasi Perubahan Suhu dan Curah Hujan serta Proyeksinya di Kota Semarang. In Proceeding Biology Education Conference: *Biology, Science, Environmental, and Learning*, 14(*1*), pp. 241-246).

Suwarman, R., Riawan, E., Simanjuntak, Y. S. M., & Irawan, D. E. (2022). Kajian Perubahan Iklim di Pesisir Jakarta Berdasarkan Data Curah Hujan dan Temperatur. *Buletin Oseanografi Marina*, 11(*1*), 99-110.

Tuejeh, H., Meylani, E. S., & Jalaludin, M. (2023). The Effect of Temperature on the Development of Seagrass in the Waters of Pramuka Island, Kepulauan Seribu Regency, Jakarta, Indonesia. *Jurnal Geografi Gea*, 23(*1*), 1-7.

Tulak, N., Bungkang, Y., & Huda, H. (2022). Analisis spektral data curah hujan dan kejadian curah hujan ekstrim di wilayah Kota Jayapura. *Jurnal Meteorologi dan Geofisika*, 23(*1*), 47-54.

Wang, X., Hou, X., & Zhao, Y. (2021). Changes in consecutive dry/wet days and their relationships with local and remote climate drivers in the coastal area of China. *Atmospheric Research*, 247, 105138.

Zarrin, A., & Dadashi-Roudbari, A. (2021). Projected consecutive dry and wet days in Iran based on CMIP6 bias-corrected multi-model ensemble. *Journal of the Earth and Space Physics,* 47(*3*), 561-578.

DOI: https://doi.org/10.17509/gea.v24i1.62607
p- ISSN 1412-0313 e- ISSN 2549-7529

Zhang, Q., Singh, V. P., Li, J., & Chen, X. (2011). Analysis of the periods of maximum consecutive wet days in China. Journal of Geophysical Research: Atmospheres, 116(D23).

Zhu, Y. Y., & Yang, S. (2020). Evaluation of CMIP6 for historical temperature and precipitation over the Tibetan Plateau and its comparison with CMIP5. *Advances in Climate Change Research*, 11(*3*), 239-251.

Zong, X., Yin, Y., Cui, T., Hou, W., & Deng, H. (2023). Spatiotemporal analysis of consecutive extreme wet days in China from 1980 to 2020. *International Journal of Climatology*, 43(*6*), 2975-2988.

DOI: https://doi.org/10.17509/gea.v24i1.62607
p- ISSN 1412-0313 e- ISSN 2549-7529