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Potential Attack of Rice Field Rat (*Rattus argentiventer*) on Rice Crops Based on Climate Factors in Karawang Regency, West Java, Indonesia

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Abstract

The production of rice is closely related to the presence of pests, one of which is the rice field rat (*Rattus argentiventer*). The pests that attack crops are influenced by the dynamics of climate factors, both directly and indirectly. The climate in Karawang Regency is highly suitable for the growth of rice field rats. In the rice-rice-intercrop cropping pattern, climate factors strongly influence the infestation of rice field rats during the intercrop season. Meanwhile, climate factors have a low influence during the rice mono-crop season. This research aimed to analyze the potential for attacks by rice field rats based on current and 2070s climate conditions using climate change scenarios in Karawang Regency, West Java, Indonesia. Work procedures include climate data validation and correction, statistical analysis of climate parameters, cropping study area data, climate data, and study area, and calculation of ecoclimatic index values. Climate and regional data were input into CLIMEX 4.0 software, which has two main functions: Comparing locations and years. Based on CLIMEX output, the altitude difference in Karawang Regency does not significantly affect the environment suitability for the growth and development of rice field rats, allowing them to live in any rice field in Karawang Regency. Based on climate scenarios, the suitability of the climate in Karawang Regency for the potential growth and development of rice field rats is projected to decrease in the 2070s. Increasing temperatures and decreasing rainfall cause the rice field rats to experience dry stress.

Keywords: Climate change scenario, *CLIMEX 4.0,* population decrease, rainfall, temperature

Introduction

One of the focus commodities in the Indonesian food agriculture sector is rice (*Oryza sativa* Linnaeus). Rice is the staple food of almost all Indonesian people. The high and low levels of rice production cannot be separated from the presence of pests, one of which is the rice field rat (*Rattus argentiventer*). Rice field rats cause damage and loss almost every planting season (Siregar et al., 2020). The Agricultural Data and Data

Center (2018) noted that rice field rats are the primary pest of rice with the highest level of puso attacks. Research by Siregar et al. (2020) states that the population level and mobility determine 94% of the damage intensity to rice plants due to rice field rat attacks. They can damage all stages of plant growth in a short time, leaving only one or two rows of clumps on the edge (Ministry of Agriculture, 2013).

The development of pests that attack crops is influenced by the dynamics of climate factors, both directly and indirectly. Temperature, relative humidity, and photo periodicity directly affect pests' life cycle, prevalence, and lifespan. The magnitude of the influence of climatic factors will differ for each species (Siahaya 2014). In this case, field rats will depend more on rice production and human efforts to eradicate their population. However, abiotic environmental conditions will also influence its vitality to some extent.

Research on potential pest attacks is vital to support integrated pest management programs. Sharma (2010) states that climate change can affect the diversity and abundance of pest geographic distribution, population dynamics, pest habitat, plant-herbivore interactions, activity, and species extinction. The IPCC has conducted a climate scenario study to determine global and regional climate change projections until 2100. This projection is needed to determine future climate conditions based on climate scenarios known as Representative Concentration Pathways (RCP) (Surmaini and Faqih, 2016). This RCP scenario defines 4 trends in the evolution of greenhouse gas emissions throughout the 21st century: a strict mitigation scenario (RCP2.6), medium scenarios (RCP4.5 and RCP6.0), and a scenario with very high greenhouse gas emissions. high (RCP8.5) (Bienvenido-Huertas et al., 2021). The impact and suitability of climate on pest attacks can be determined using the CLIMEX model.

CLIMEX uses the principle that the distribution of a species informs the environment in which it can survive. CLIMEX also characterizes the relationship between the environment and the distribution of a species using eco-physiological parameters that regulate species survival and population growth rates under four stress indices, namely cold, hot, wet, and dry (Early et al., 2022). The combination will produce an eco-climatic index (Koesmaryono et al., 2004). This research aims to analyze the potential for attacks by rice field rats (*R. argentiventer*) based on current and 2070s climate conditions using climate change scenarios in the Karawang Regency.

Methods

This research used tools in the form of laptops with Microsoft Office, Minitab 21, ArcMap 10.8, and CLIMEX 4.0 software. The data used is shown in Table 1.

Table 1. Data used in research

No.	Data Type	Source
1	Station observation daily climate data BMKG Kemayoran year 2013-2022	http://dataonline.bmkg.go.id
2	Daily climate data reanalysis ERA5 year 2013-2022	https://cds.climate.copernicus.eu/
3	Climate change scenario data RCP 4.5 and 8.5 year 2070	http://ccafsclimate. org/data_spatial_downscaling/
4	Pest physical parameters *R. argentiventer*	*Template-wet Tropical* CLIMEX
5	Widespread pest attack *R. argentiventer* year 2013-2022	BPTPH West Java Province

Work Procedures

Climate data validation and correction

Climate data validation was carried out to determine the accuracy of NASA Power's reanalysis climate data with the Kemayoran Meteorology, Climatology, and Geophysics Council Station (MCG-CS) observation climate data in Jakarta. Climate data correction is used to improve the quality of ERA5 data using climate data from the MCG-CS Kemayoran Station. This correction used simple regression analysis (Nawari 2010).

$$y = ax + b \quad \text{(1)}$$

Note: y (MCG-CS Kemayoran Station observation climate data) = dependent variable, x = independent variable (NASA Power reanalysis climate).

According to Mamenun et al. (2014), there are four methods for analyzing the level of accuracy of observation data with reanalysis data before and after correction, namely Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Pearson correlation coefficient (r), and average bias relative (Bias).

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(satellite_i - observation_i)_i^2} \quad (2)$$

$$\text{MAE} = \frac{1}{n}\sum_{i=1}^{n}|satellite_i - observation_i| \quad (3)$$

$$r = \frac{\sum_{i=1}^{n}(observation_i-\overline{observation})(satellite_i-\overline{satellite})}{\sqrt{\sum_{i=1}^{n}(observation_i-\overline{observation})^2(satellite_i-\overline{satellite})^2}} \quad (4)$$

$$\text{Bias} = \frac{\sum_{t=1}^{n}(observation_i-satellite_i)}{\sum_{t=1}^{n}observation_i} \times 100\% \quad (5)$$

Statistical Analysis of Climate Parameters

Quadratic regression analysis is a way to model the relationship between two sets of variables. The result is a regression equation that can be used to make predic-tions about the data. This type of regression is an extension of simple linear regression to find the straight-line equation that best fits a set of data. Quadratic nonlinear regression analysis using a polynomial model was used to determine the influence of climate parameters on the extent of pest attacks in this study with the following equation (Walpole 1995):

$$Y = \beta_0 + \beta_1 X + \beta_2 X^2 \quad (6)$$

Note: Y = Extent of attack *R. argentiventer,* β = Constant, X = Temperature, Relative Humidity, or Rainfall

Cropping Study Area Data

The climate change scenario data in this research used RCP 4.5 and 8.5 for the 2070s, which were projections from the Commonwealth Scientific and Industrial Research Organization (CSIRO) and the Model for Interdisciplinary Research on Climate 5 (MIROC5). Both have a spatial resolution of 30 sec with *asc format processed using ArcMap 10.8 software. The data was cut using the Clip Data Management tool according to the study area so that the observed area was centered. The result was climate parameter data according to climate change scenarios with monthly resolution, which needs to be converted using *.mm format documents as input to the Compare Locations function in CLIMEX.

Climate Data and Study Area

Climate data and regional data for Karawang Regency were input into CLIMEX 4.0 software which has two main functions, namely Compare Locations and Compare Years. In the Compare Locations function, regional data and climate data are entered which consist of latitude, longitude, altitude, air temperature (T), rainfall, and relative humidity (RH). The data entered for Compare Locations is divided into two files, namely the study area location file (LOC file) which consists of latitude, longitude and altitude, and the monthly climate data file (MET file) which consists of minimum temperature, maximum temperature, rainfall, as well as maximum and minimum relative humidity created in Microsoft Access software in *mm format. In the Compare Years function, daily climate time series data was entered which consists of maximum and minimum air temperature (T), rainfall, and maximum and minimum humidity (RH) data in *prn format.

Calculation of Ecoclimatic Index Values

Weekly Growth Index (GI_W)

Formula equation GI_W:

$GI_W = TI_W \times MI_W \times LI_W \times DI_W$ .... (7)

Note: GI_W = Weekly Growth Index, LI_W = Weekly Light Index, TI_W = Weekly Temperature Index, DI_W = Weekly Diapause Index, MI_W = Weekly Moisture Index

Annual Growth Index (GI_A)

Formula equation GI_A:

$$GI_A = \frac{100 \sum_{i=1}^{52} GI_W}{52} \quad (8)$$

Note: GI_A = Annual Growth Index, GI_W = Weekly Growth Index

Stress Index (SI)

Formula equation Stress Index (SI):

$$SI = \left(1-\frac{CS}{100}\right)\left(1-\frac{DS}{100}\right)\left(1-\frac{HS}{100}\right)\left(1-\frac{WS}{100}\right) \quad (9)$$

Note: CS = Cold Stress, HS = Hot Stress, DS = Dry Stress, WS = Wet Stress

Stress Interaction Index (SX)

Formula equation Stress Interaction Index (SX):

$$SX = \left(1-\frac{CDX}{100}\right)\left(1-\frac{CWX}{100}\right)\left(1-\frac{HDX}{100}\right)\left(1-\frac{WWX}{100}\right) \quad (10)$$

Note: CDX = Cold-dry stress interaction index, CWX = Cold-wet stress interaction index, HDX = Hot-dry stress interaction index, HWX = Hot-wet stress interaction index

Ecoclimatic Index (EI)

Ecoclimatic Index (EI) is a value to determine the potential for rice field rat attacks by taking into account the suitability of the climate of Karawang Regency with the characteristics of rice field rat pests. Clasification Ecoclimatic Index (EI) could be seen in Table 2.

Formula equation Ecoclimatic Index (EI):

$$EI = TGI_A \times SI \times SX \quad (11)$$

Note: GI_A = Annual Growth Index, SI = Stress Index, SX = Stress Interaction Index

Table 2. Clasification Ecoclimatic Index (EI)

Value of EI	Information
0-25	It is not in accordance with
26-50	Not suitable
51-75	Suitable
76-100	Very suitable

Source: D'adamo et al. (1998) in Koesmaryono et al. (2004)

Results

Validation Analysis of Corrected Climate Data

The results of validation of bias correction for Karawang Regency ERA5 climate data is shown in Table 3.

Table 3. Validation value of ERA5 data correction to observation data

Parameter	Before Correction				After Correction			
	RMSE	r	MAE	Bias	RMSE	r	MAE	Bias
Rainfall	16.64	0.31	7.74	8.35	2.75	0.87	1.56	-0.003
Relative Humidity	4.40	0.77	3.49	-1.96	2.63	0.84	2.05	-0.005
Temp. min	1.83	0.53	1.35	-5.06	0.19	0.92	0.15	-0.002
Temp. max	5.02	0.65	4.89	15.09	0.33	0.94	0.26	-0.002
Temp. mean	1.03	0.81	0.90	2.92	0.33	0.93	0.26	0.00002

Comparison of observational data, ERA5, and corrected ERA5 on variables rainfall, air humidity, minimum temperature, maximum temperature, and average temperature can be seen in Figure 1.

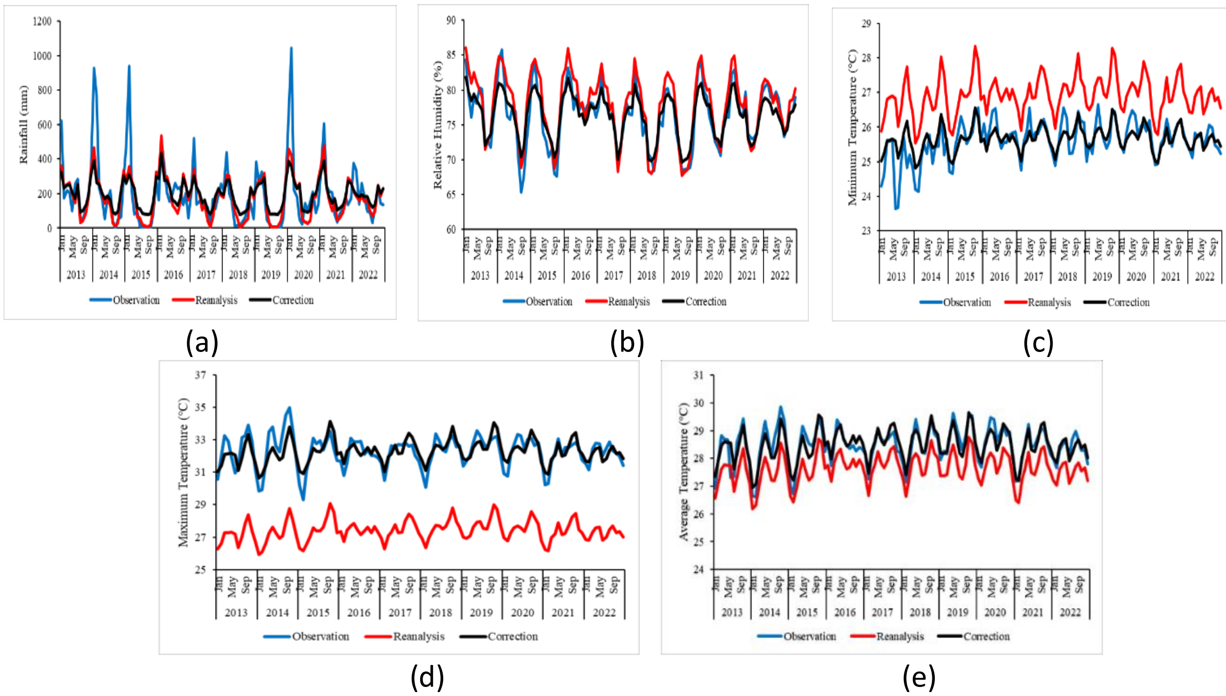
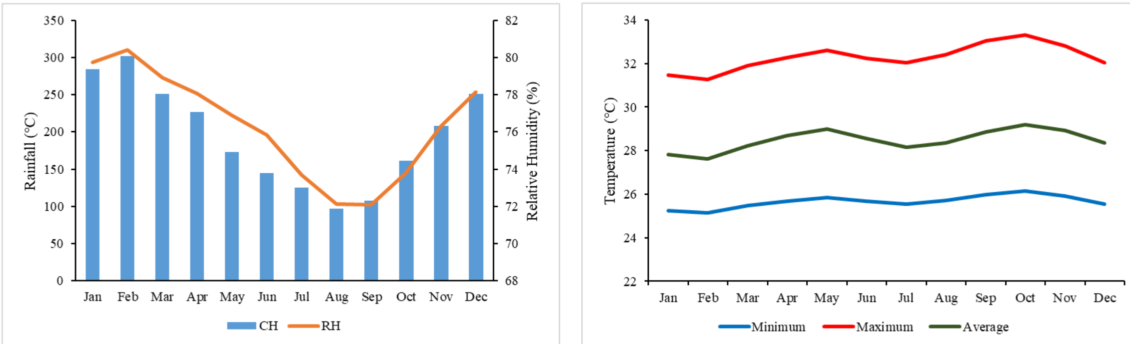


Figure 1. Comparison of observational data, ERA5, and corrected ERA5 on variables rainfall (a), air humidity (b), minimum temperature (c), maximum temperature (d), and average temperature (e)

Analysis of Climate Conditions

Karawang Regency, Indonesia, is in the northern part of West Java Province between 107°02'–107°40' East Longitude and 5°56'–6°34' South Latitude, which has 30 sub-districts. The area is 1,911.09 km² or 4.72% of the area of West Java Province. Most of the land in Karawang Regency is used for agriculture because it is one of the areas with fertile land in West Java. The land is mostly relatively flat plains and varies between 0-5 meters above sea level. Only a small part of the area is undulating and hilly, with a height between 0–1,200 meters above sea level. A wide coastal plain stretches across the northern coast of Karawang Regency with sedimentary rocks formed by loose materials, especially marine sediments, and volcanic alluvium. The center is hills, formed mainly by sedimentary rocks. In accordance with its morphology, Karawang Regency consists of lowlands (BPS 2023).

Karawang Regency is an area with a monsoon rain pattern. The monsoonal rain type has a noticeable difference between the dry and rainy seasons (Apriyana and Kailaku 2015), with the dry season occurring in the middle of the year and the rainy season occurring at the end of the year. During 2013-2022, the average monthly rainfall ranges from 97-301 mm. The highest rainfall occurs in February, and the lowest occurs in August. The relative humidity of the air increases and decreases relatively the same as rainfall, with a range of 72-81%. Meanwhile, air temperatures are relatively constant throughout the year, with minimum temperatures ranging from 25.2-26.2°C, average temperatures from 27.6-29.2°C, and maximum temperatures from 31.2-33.3°C (Figure 2). The lowest air temperature occurs in February, and the highest occurs in October.



(a) (b)

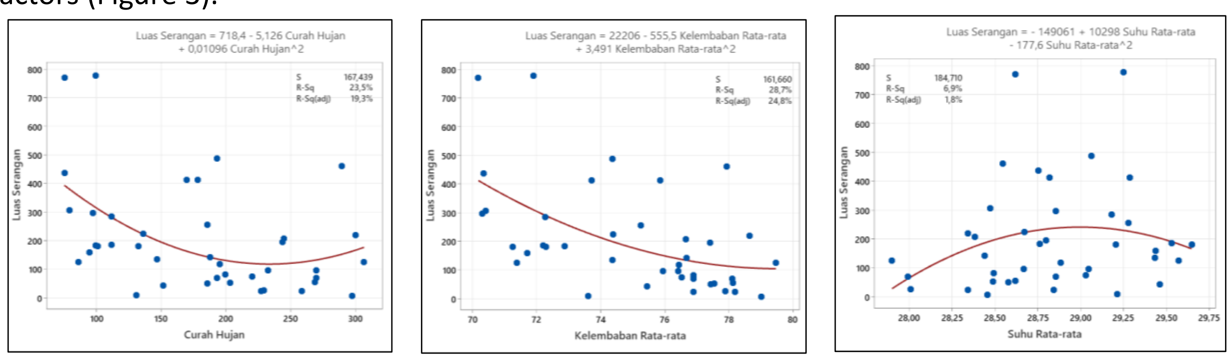
Figure 2. Graph of monthly rainfall and relative humidity (a) and air temperature (b) in Karawang Regency 2013-2022

Influence Climate Factors on the Extent of *Rattus argentiventer* Attacks

The R-square value of the rainfall predictor is 23.47%, the air humidity predictor is 28.66%, and the air temperature predictor is 6.86%. This value states that the climate factors that have the most and least influence on the growing season for *rendeng* rice are air humidity and air temperature. These three predictors have an R-square value of 36.96% for the response variable, so it can be interpreted that the influence of rainfall, air humidity, and air temperature together on the area of *R. argentiventer* attack in the *rendeng* rice planting season is 36.96% and the remaining 63.04% is influenced by other factors (Figure 3).

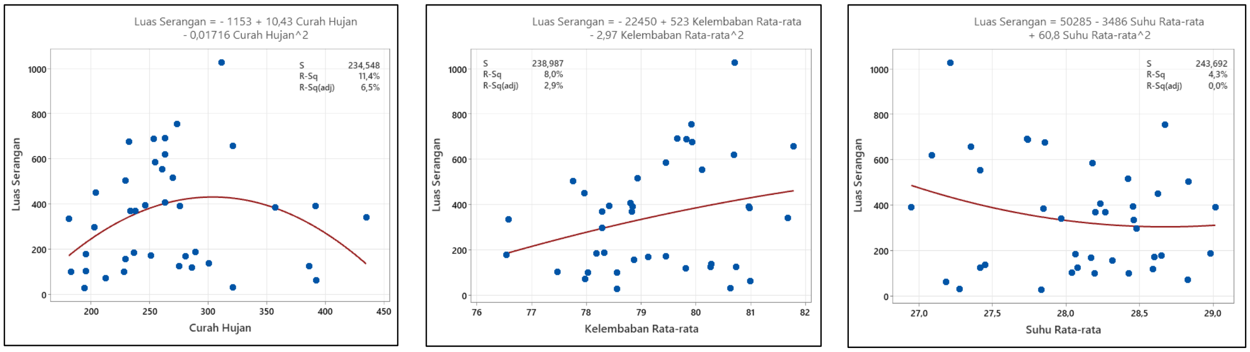
The R-square value of the rainfall predictor is 11.38%, the air humidity predictor is 7.99%, and the air temperature predictor is 4.33%. This value states that the climate factors that have the most and least influence on the *gadu* rice planting season are rainfall and air temperature (Figure 4).

These three predictors have an R-square value of 22.80% for the response variable, so it can be interpreted that the influence of rainfall, air humidity, and air temperature together on the area of *R. argentiventer* attack in the *gadu* rice planting season is 22.80% and the remaining 77.20% is influenced by other factors.



(a) (b) (c)

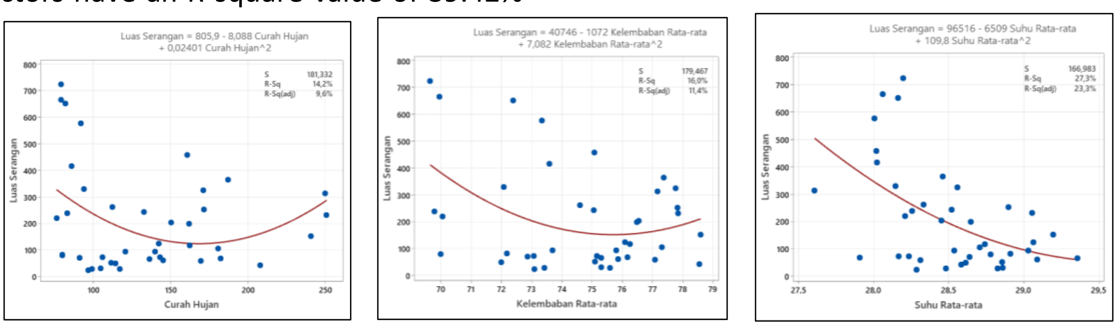
Figure 3. Nonlinear regression results of the extent of *R. argentiventer* pest attacks on rainfall (a), air humidity (b), air temperature (c) during the *rendeng* rice growing (wet season) in Karawang Regency



(a) (b) (c)

Figure 4. Nonlinear regression results of the extent of *R. argentiventer* pest attacks on rainfall (a), air humidity (b), and air temperature (c) during the *gadu* rice planting (dry season) in Karawang Regency

The R-square value of the rainfall predictor is 14.21%, the air humidity predictor is 15.97%, and the air temperature predictor is 27.25%. This value states that the climate factors that have the most and least influence on the secondary crop growing season are air temperature and rainfall. These three predictors have an R-square value of 39.42% for the response variable, so it can be interpreted that the influence of rainfall, air humidity and air temperature together on the area of *R. argentiventer* attack in the secondary crop growing season is 39.42% and the remaining 60.58 is influenced by other factors (Figure 5).



(a) (b) (c)

Figure 5. Nonlinear regression results of the extent of *R. argentiventer* pest attacks on rainfall (a), air humidity (b), and air temperature (c) during the secondary crop (*palawija*) growing season in Karawang Regency

The difference in planting seasons is related to how much climatic factors influence the extent of rice field rat attacks in Karawang. Of the three planting patterns, the influence of climatic factors is greatest during the secondary crop planting season when rats are less dependent on rice growth, with the climate factor that has the greatest influence on rat attacks being air temperature. On the other hand, the smallest influence of climatic factors occurs during the *gadu* rice planting season. The three climatic factors simultaneously decrease their influence on the *gadu* rice season because rat attacks depend on rice growth. The order of climatic factors that influence it is also inversely proportional to the secondary crop season: rainfall-air humidity-air temperature for the rice at *gadu* season and air temperature – air humidity - rainfall for the secondary crops season. Meanwhile, the influence of climatic factors on the growing season for *rendeng* rice together has a relationship value that is not much different from the planting season for secondary crops. However, the most influential climatic factor in this season is air humidity, followed by rainfall.

Weekly Growth Index (GIw)

The growth index describes the potential for population increase during favorable seasons (Figure 6). Apart from multiplying the temperature, humidity, light, and diapause indices, the Weekly Growth Index (GIw) can also be calculated by multiplying the Total Weekly Growth Index (TGIw) and the Weekly Biotic Index (BIw). BIw represents the observed interactions of a species with other species, such as competition or symbiosis. When no species interactions are considered, BIw is automatically set to 1, so GIw equals TGIw (Jung et al., 2016). GIw added and enlarged to a scale between 0-100 will give the Annual Growth Index (GI) value (Maywald and Sutherst 1989).

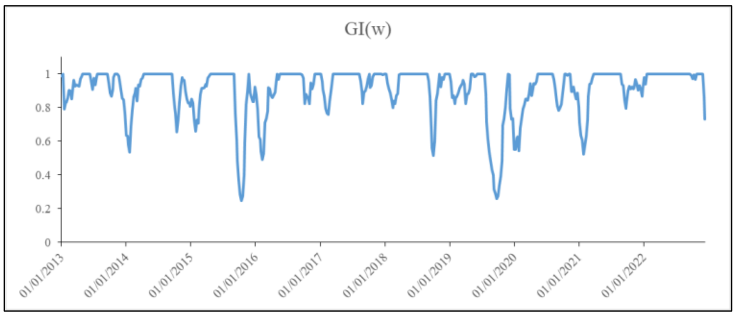


Figure 6. Weekly Growth Index graph of the pest *R. argentiventer* in Karawang Regency during the year 2013-2022

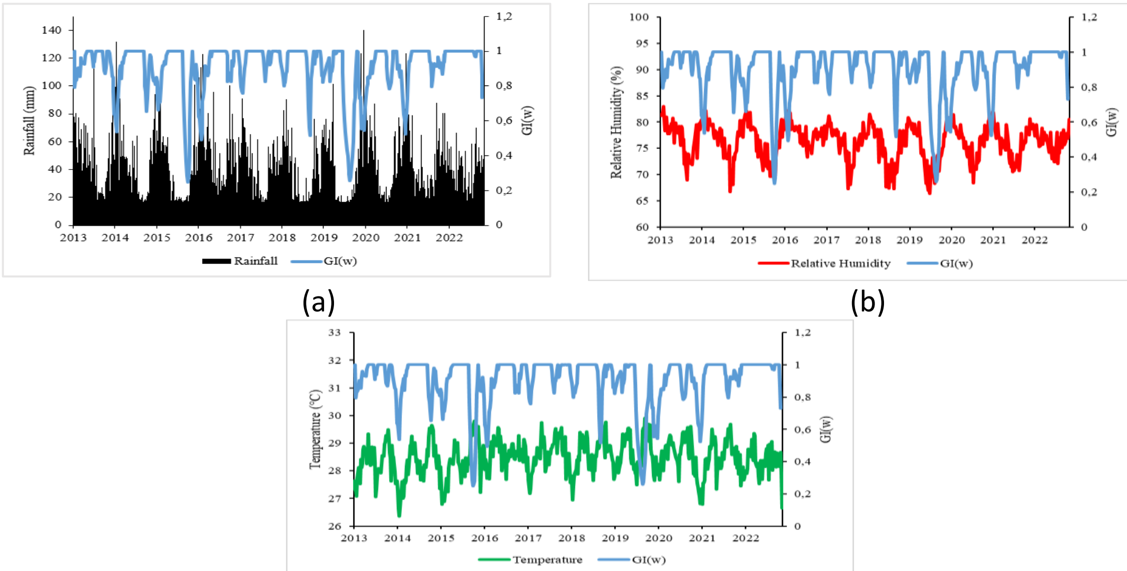
The amount of rainfall linearly with air humidity shows a negative response to GIw. If rainfall and air humidity increase, GIw will tend to be low. On the other hand, air temperature parameters can be said to have a positive response to GIw. When air temperature increases, GIw will also tend to increase. However, anomalies occurred in 2015 and 2019 (El Niño years) when decreasing rainfall and air humidity showed a positive linear response, so GIw also reduced. This also applies vice versa for air temperature parameters (Figure 7).

Level of Life Suitability of Rice Field Rat Pests

A CLIMEX output ecoclimatic index (EI) value that is close to zero means that the observed species cannot live in that location, while an EI greater than 30 means that the observed species can thrive in that area. The growth index in this model is based on temperature, soil moisture, radiation, substrate (the surface on which a species lives), the amount of light it is exposed to, and diapause ability, while the stress index is calculated from cold stress (CS), heat stress (HS), wet stress (WS), and dry stress (DS), all four of which are limiting factors for species populations (Table 4).

Potential for Rice Field Rat Pest Attacks

Modern agriculture has helped farmers increase crop yields, but future agricultural systems must integrate sustainability. Farmers' current practices can have a major impact on the environment due to excessive use of pesticides and fertilizers, thereby increasing greenhouse gas emissions that cause and exacerbate climate change. Abiotic factors influenced by climate change are extreme temperature variations, stronger and more widespread storms and floods, and drought. Unpredictable earth temperatures due to climate change can reduce crop yields and increase the risk of pest and disease attacks on plants (Costa et al., 2018).



(a) (b)

(c)

Figure 7. Graph of the relationship between the Weekly Growth Index of the pest *R. argentiventer* with rainfall (a), air humidity (b), and air temperature (c) in Karawang Regency in 2013-2022

Table 4. CLIMEX output on altitude in Karawang Regency

Altitude	EI	GI	MI	TI	CS	DS	HS	WS
0 m	94	94	95	99	0	0	0	0
25 m	91	91	93	97	0	0	0	0
50 m	86	86	90	94	0	0	0	0
150 m	82	82	86	94	0	0	0	0

A comparison of climate fluctuations in the baseline 2013-2022 and the 2070s in the CSIRO and MIROC models. Rainfall in the 2070s is almost lower than the baseline year, except for CSIRO 4.5 in February (Figure 8). Both models show different variations in rainfall distribution throughout the year. Regardless of the scenario, the CSIRO model shows a decrease in rainfall starting in May and no significant increase until the end of the year. Meanwhile, the MIROC model shows an increase in rainfall in September and continues to increase until the end of the year. Meanwhile, rainfall anomalies based on the scenarios show that the RCP 8.5 scenario has relatively lower rainfall than RCP 4.5 and the baseline year. Costa et al. (2018) stated that climate change impacts prolonged drought due to low air humidity and rainfall.

The maximum and minimum temperatures in Figure 8 show varying values. The temperature at the baseline is relatively constant throughout the year, while the temperature in the 2070s fluctuates. Minimum temperatures will increase until May, decrease until September, and increase again until the end of the year. The minimum temperature in the 2070s is lower than the baseline year, while the maximum in the 2070s is higher than the baseline year. The maximum temperature increases until it peaks in October-November and decreases in December. This temperature anomaly occurs in the RCP 4.5 scenario, which is in the anomaly range of 1.1-2.6°C, and in the RCP 8.5 scenario, is in the anomaly range of 2.6-4.8°C (IPCC 2013).

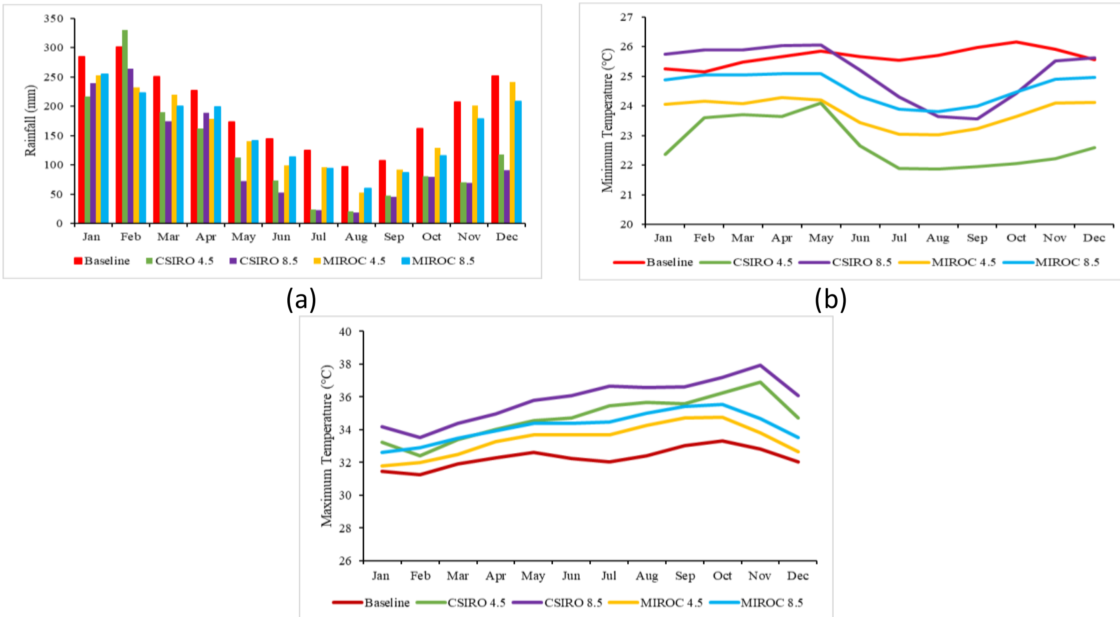


Figure 8. Comparison graph of fluctuations in rainfall (a), minimum temperature (b), and maximum temperature (c) of the baseline year with the 2070s CSIRO and MIROC models

Handoko et al. (2008) stated that the consequences of climate change for Indonesia are changes in seasons and rainfall, increasingly extreme weather conditions, rising sea levels, warming ocean temperatures, and increasing air temperatures. Both scenarios from CSIRO and the RCP 8.5 scenario from MIROC have EI values that are included in the "not suitable" classification, while the EI values in the RCP 4.5 scenario from MIROC are included in the "less suitable" range. The decline in the EI value was also followed by a decrease in other growth indices (Table 5).

Table 5. CLIMEX output for the baseline year and 2070s for Karawang Regency

Output	Baseline (2013-2022)	Year 2070s			
		RCP 4.5		RCP 8.5	
		CSIRO	MIROC5	CSIRO	MIROC5
EI	94	10	29	4	19
GI	94	18	31	10	20
MI	95	19	32	15	23
TI	99	43	78	19	59
CS	0	0	0	0	0
DS	0	45	8	59	7
HS	0	0	0	0	0
WS	0	0	0	0	0

When all indices supporting the growth of field mice decreased, the dry stress (DS) limiting index increased in the 2070s. According to Kriticos et al. (2015), dry stress is usually at a soil moisture level of 0.1, equivalent to the permanent wilting point, although some plants can tolerate this threshold before experiencing stress. Most animals will require the presence of growing plants to thrive. Therefore, the soil moisture threshold for animals follows a logic similar to that of their host plants. Indirectly, these results also show that *Oryza sativa* is unsuitable for growing in Karawang Regency in the 2070s based on the RCP 4.5 and 8.5 scenarios. This can happen because the model does not include irrigation factors and only considers total rainfall.

Discussion

Validation Analysis of Corrected Climate Data.

RMSE measures the average of the squared error values. These differences or errors occur due to randomness or because the estimator does not consider things that could produce more accurate estimates. All corrected parameters experienced a decrease close to zero in RMSE. Ideally, the RMSE value should be zero (Ali and Abustan, 2014). ERA5 rainfall data before correction had an RMSE value of 16.64 mm/day and after correction had an RMSE value of 2.75 mm/day or a decrease of 84%. The RMSE value for rainfall prediction varies for each different model and is still said to be good if it is in the range of 10-30 mm/day or lower, depending on the spatial and temporal scale. Research by L´opez-Bermeo et al. (2022) produces RMSE for rainfall parameters in the range of 9-22 mm/day which varies based on location. Meanwhile, the parameters relative humidity (RH), minimum temperature (T min), maximum temperature (T max), and average temperature (T mean) respectively also experienced a decrease in RMSE values of 40%, 90%, 93%, and 70%.

Pearson correlation coefficient (r) measures the strength of the linear relationship between ERA5 data and observational data. This value will show how well the ERA5 data points match the observed data pattern obtained by dividing the covariance between the two variables by the product of their standard deviations (Pearson 1920). The Tmean parameter has the largest correlation value and CH has the smallest correlation value before correction is carried out. The five parameters experienced an increase in correlation value after correction to 0.84-0.94. This figure is close to +1, which means that there is a positive relationship between ERA5 data and observation data. This shows that if the value of one of them increases, the value of the other will also increase.

Apart from RMSE, there is MAE which is used to measure model validation. Although both have been used to assess the performance of a model for many years, there is no common agreement among researchers regarding the most appropriate metric for model error (Chai and Draxler 2014). The five parameters showed MAE values that decreased or approached zero after bias correction, as in research conducted by Irwandi et al. (2023). MAE values decreased by 93%, 41%, 89%, 95%, and 71% for CH, RH, Tmin, Tmax, and Tmean respectively.

Influence of Climate Factors on the Extent of *Rattus argentiventer* Attacks

The development of rice field rats (*R. argentiventer*) is closely related to the availability of abundant and good quality food, thus supporting optimal breeding (Htwe *at al.* 2012). Rice production that is in line with planting patterns will influence the breeding of rice field rat, which is known to occur during the generative rice growth period (Sudarmaji 2004). The planting season is divided into three with a rice - rice - palawija pattern. The first rice planting season occurs in September-December, the second rice planting season occurs in January-April, and the secondary crop (crops other than rice) planting season occurs in May - August.

Data on the area of monthly rice field rat attacks during 2013-2022 obtained from BPTPH West Java were classified by rice - rice

- *palawija* (secondary crop) planting time and added up. The total area of rice field rat attacks over 10 years in the first rice planting season (*rendeng* = wet season) was 8,092 ha, the second rice planting season (*gadu* = dry season) was 13,487 ha, and the secondary crop planting season was 8,283 ha. Rice field rats are not able to reproduce optimally in secondary crops, so the number of children they give birth to is not as large as when there are rice plants. The area of attack will increase during the *rendeng* (wet) rice planting season, decrease slightly at rice harvest time, and increase again until it reaches its peak at the end of the *gadu* (dry) rice planting season. After that, the attack will decrease until it returns to the starting point with the same attack or slightly higher than at the beginning of the *rendeng* (wet) rice planting season.

The difference in planting seasons turns out to be related to how much influence climatic factors have on the extent of rice field rat attacks in Karawang. Of the three planting patterns, the influence of climatic factors is greatest during the secondary crop planting season when field mice are less dependent on rice growth, with the climate factor that has the greatest influence on rice field mouse attacks being air temperature. On the other hand, the smallest influence of climatic factors occurs during the *gadu* rice planting season. These three climatic factors simultaneously decrease their influence on the *gadu* rice season because rice field rat attacks are very dependent on rice growth. The order of climatic factors that influence it is also inversely proportional to the secondary crops season, namely rainfall - air humidity - air temperature for the rice *gadu* season and air temperature - air humidity - rainfall for the secondary crops season. Meanwhile, the influence of climatic factors on the growing season for *rendeng* rice together has a relationship value that is not much different from the planting season for secondary crops. However, the most influential climatic factor in this season is air humidity, followed by rainfall.

***Weekly Growth Index* (GIw)**

The Weekly Growth Index (GIw) graph depicts the suitability of the weekly climate for the growth of rice field rats, without reference to life cycle stage or generation (Kriticos et al., 2015). In general, rice field rats can live all year round because they do not experience a GIw value equal to zero. The GIw value of rice field rats in Karawang Regency ranges from 0.25 to 1 during 2013-2022. This value will decrease in August-September or at the beginning of the *rendeng* rice planting season and will increase in January-February or at the beginning of the *gadu* rice planting season. During the planting season for *gadu* rice and secondary crops, GIw tends to be 1. The lowest GIw value for 10 years occurred in October 2015 with an index of 0.25. This is in line with the strengthening of El Niño in 2015 (Santoso et al., 2017) which caused a long dry season. According to Meijide et al. (2018), the 2015 ENSO event caused warmer and drier conditions than the previous two years. Apart from that, low GIw values also occurred in September 2019. This condition also occurred due to the emergence of El Niño, although it was weak.

Level of Life Suitability of Rice Field Rat Pests

Karawang Regency is an area that is mostly lowland and coastal with the highest area being in Tegalwaru District, namely 104 meters above sea level. Table 4 shows the values of EI, GI, MI, TI, CS, DS, HS, and WS for altitude in Karawang Regency. Four indexes support the growth of rice field rats (EI, GI, MI, and TI) tends to decrease with height. However, this range of values is still within the "very suitable" classification (D'adamo et al., 1998 in Koesmaryono et al., 2004). The stress index for rice field mice at each altitude is zero, which means that differences in altitude in Karawang Regency do not have a significant influence on the suitability of the environment for the growth and development of field mice. Table 4 also shows that Karawang Regency has a very suitable climate for R. argentiventer. This is in line with the regional problem caused by the rice field rat outbreak (BPTPH 2023).

Conclusion

The climate in Karawang Regency is very suitable for the population growth of *R. argentiventer*, so the potential for attacks is very high. In the rice-ricepalawija planting pattern, climatic factors strongly influence attacks by rice field rats during the secondary crop planting season. Meanwhile, climatic factors do not influence the *gadu* (dry) rice planting season. Differences in altitude in Karawang Regency do not significantly affect the suitability of the environment for the growth and development of the rice field rats population, so rice field rats can live in any rice field in Karawang Regency. Based on the climate scenario, the level of climate suitability of Karawang Regency in the 2070s to the potential climate for the growth and development of rice field rats will decrease. Rising temperatures and decreasing rainfall cause rice field rats to experience dry stress combined with reduced food sources.

Declaration

Author contribution

Lupita Aprilia is the main contributor for this paper. Swastiko Priyambodo is corresponding author. Yonny Koesmaryono is co-author. All authors read and approved the final paper.

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Competing interest

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