Climate Variability Detection at Kuningan Experimental Garden

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ABSTRACT
Climate variability is global phenomenon that may affect water availability in water user. Long-term climate variability detection is then crucial to water resources planning and management. This study was conducted to analyze climate variability and trend evaluation over Kuningan Experimental Garden, Ministry of Agriculture of Indonesia. The observed data is recorded through automatic weather station at Kuningan Experimental Garden which has period from 1985 to 2020. Statistical approach was applied to assess the homogeneity, correlation, trend and slope. The result of climate variability test has an increasing trend at annual rainfall, monthly maximum temperature and minimum temperature based on the Mann – Kendall test as well a positive trend by as the Sen's slope estimator by either 1% or 5 % of significance level. This information could be useful for water availability planning in agriculture sector.

Keywords: *climate variability, Mann-Kendall test, water availability*

1. INTRODUCTION

Climate change becomes important issue in the world. Global climate changes may affect rainfall patterns impacting the availability of water. In addition, it increases occurrences of droughts and floods [1]. The rainfall is one of factors in determining the water supply to meet water demands such as agricultural, industrial, domestic and for hydroelectric power generation. Indonesia develops agriculture sector as the main economic growth which depends on climate variability, it is vital to investigate the trends of climate. Therefore, knowledge understanding of trends in climate variable is very important for better water resource planning in a river basin especially agricultural water use in a region.

Many researchers suppose that rainfall is single main variable indicating climate change. the climate trend analysis has been employed in Southeast Asia. Several studies have verified historical trends of climate variability in Global. Study extreme rainfall trend in Southeast Asia (Myanmar, Thailand and northern Vietnam) shows a downward trend, otherwise an increase trend occurs in southern Vietnam and Luzon, Philippines [2]. Another study provides a significant increase annual rainfall in northwest Ho Chi Minh city influenced regional factors [3]. In fact, climate change detection is influenced another variable such as humidity, temperature and solar radiation [4,5].

Statistical approach is well-known applied on climate trend analysis. One of method is useful parametric methods which are restricted to normally distributed time series. Because the time series climatic data would not normal distribution, non-parametric methods are alternative frequently applied in trend analysis [6,7,8]. In addition, the methods are considered more robust than parametric methods against the outliers in a time series.

This study is to clarify the climate variability in terms of intensity and frequency over the Kuningan region, Indonesia, using ground station data. The analysis of the climate trends is conducted based on the relationships among rainfall, temperature, wind speed and humidity. Major finding in this study is to provide climate variability information at center of rice producer area.

2. MATERIAL AND METHOD

2.1. Data

Climate data such as temperature, relative humidity, global radiation and rainfall is recorded at ground station, experimental garden, Cibentang, Kuningan West Java. This study use data period of 1985-2020 which missing data is fullfilled by statistical approach from https://power.larc.nasa.gov/data-access-viewer/. The ground station is located at 6.950187 S, 108.473747 E.

2.2. Method

2.2.1. Correlation test

Correlation coefficient corresponds to the classical linear correlation coefficient. This coefficient is well suited for continuous data. Its value ranges from -1 to 1, and it measures the degree of linear correlation between two variables. Pearson correlation coefficient gives an idea of how much of the variability of a variable is explained by the other variable [9]:

$$r = \frac{\Sigma(x-\bar{x})(y-\overline{y})}{\sqrt{\Sigma(x-\bar{x})^2\Sigma(y-\overline{y})^2}} \quad (1)$$

where x and y are variable data, $\bar{x}$ and $\bar{y}$ are average at x and y

2.2.2. Homogeneity test

Homogeneity tests involve a large number of tests for which the null hypothesis is that a time series is homogenous between two given times. The Buishand's test can be used on variables following any type of distribution [10]. But its properties have been particularly studied for the normal case. Buishand method focuses on the case of the two-tailed test, but for the Q statistic presented the one-sided cases are also possible. In the case of the Q statistic, the null and alternative hypotheses are given by:

H_0: The variables follow one or more distributions that have the same mean.
HA: There exists a time from which the variables change of mean.

Buishand equation:

$$S_k^* = \sum_{i=1}^{k} Y_i - \bar{Y} \quad (2)$$

Where:
K = 1,2,3,…n. Yi , Value at i data time series , $\bar{Y}$ is data average

The timeseries data would have a consistency if there is no deviation between value Yi dan $\bar{Y}$. The change in the data (HA) is rejected if the computed value of P is greater than the alpha significance level (use 1 % and 5 %), while cannot reject the null hypothesis H_0.

2.2.3. Trend Mann-Kendall and Sen's Slope

A nonparametric trend test has first been proposed by Mann then further studied by Kendall and improved by Hirsch who allowed to take into account a seasonality [11,12].

The null hypothesis H_0 for these tests is that there is no trend in the series. The Mann-Kendall tests are based on the calculation of Kendall's measure of association between two samples, which is itself based on the ranks with the samples.

In the particular case of the trend test, the first series is an increasing time indicator generated automatically for which ranks are obvious, which simplifies the calculations. The S statistic used for the test and its variance are given by:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign(x_j - x_i) \quad (3)$$

Sign (Xj - Xi) is function which has value +1 if sign > 0 or -1 if sign < 0.

$$Z = \begin{cases} \frac{S-1}{\sqrt{V(S)}} & if\ S > 0 \\ 0 & if\ S = 0 \\ \frac{S+1}{\sqrt{V(S)}} & if\ S < 0 \end{cases} \quad (4)$$

The timeseries data would have a trend by computing p value. The change in the data ( ) is accepted if the computed value of P is lower than the significance level alpha (use 1 % and 5 %), while can reject the null hypothesis H_0.

Sen's slope evaluation is the value of trends slope. That means the sign of the slope tells if the trend is increasing or decreasing. Sen's Slope equation is given by:

$$\beta i = x_j - x_i / j - i \quad (5)$$

where n is the number of data points, xi and xj are the data values in time series i and j ($j > i$), respectively. The Sen's slope estimator, β, is then calculated by taking the median of βi.

3. RESULT AND DISCUSSION

3.1. Homogeneity

The results of the homogeneity test include monthly and annual data for rainfall, relative humidity, maximum temperature, minimum temperature and wind speed. The test result indicates that the recorded data period is consistent in the range of 1985 to 2020 for 36 years with a significance level of 1%. The P value (Table 1) is greater than the significance level alpha 0.01(1%), where H_0 is accepted and HA is rejected.

Table 1. Homogeneity of climate data at 1% of significance level

No	Variable	P Value		Homogeneity
		Monthly	Annual	
1	Rainfall	0.016	0.026	Consistent
2	Relative humidity	0.766	0.871	Consistent
3	Maximum temperature	0.085	0.257	Consistent
4	Wind velocity	0.150	0.319	Consistent
5	Minimum Temperature	0.05	0.068	Consistent

3.2. Correlation Test

The correlation level between variables is shown in the Table 2. The correlation test was applied to monthly data during 36 years. The maximum temperature correlation with wind speed variables shows the small linear relationship, a correlation level of less than 0.5. Mostly, the result of correlations tests shows a sufficient correlation level more than 0.5 (moderate to high relation). In addition, changes in one climate variable are associated with change with a proportional change in the other variable. The negative values express proportional change in two variables is in opposite direction. So, climate condition in Kuningan Experimental Garden is correlated to temperature, relative humidity, wind speed and rainfall.

Table 2. The correlation level of variables

No	Tmax	Tmin	Rh	W1	R
Tmax	1				
Rh	-0.858	0.504	1		
W1	0.245	-0.814	-0.559	1	
R	-0.331	0.696	0.591	-0.629	1

Ket = Tmax : Maximum temperature ; Tmin : Minimum temperature, Rh : Relative humidity , Wi : wind speed, R : rainfall

Correlation plot diagram among climate variables is visually presented in the Figure 1. The density which indicates the level of correlation between variables is relatively dense at the correlation Tmax-Rh, Tmin-R and Rh-R. This is because the value of the relationship recorded data variables from one month to the next month there is a deviation.

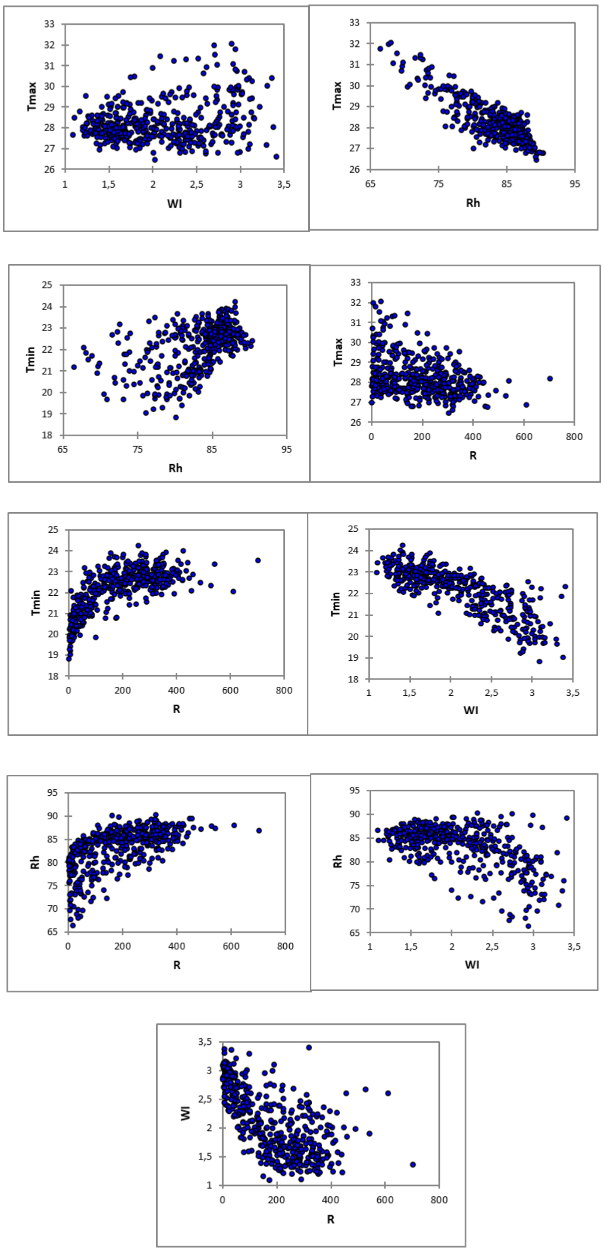

Figure 1. Plot diagram of climate variables correlation

3.3. Mann Kendall Test

Mann Kendall Trend analysis was carried out on monthly and annual climate data at 5% and 1% of significance levels (Table 2).

The trend results vary on changing climate variables, namely: the minimum temperature variable is quite convincing to experience a changing trend followed by the maximum temperature and rainfall trend. Otherwise, annual rainfall has a significant trend based on high slope and P value of 5 % significance level. This fact might express the more length of data at monthly rainfall rather than accumulative annual rainfall which cause affect high slope. Meanwhile, other variables such as relative humidity and wind speed did not experience a trend of change either monthly or annual. This is demonstrated that the p-value greater than either 0.05 or 0.01 of significance, so that the null hypothesis statement is accepted the statement indicate no trend in both increasing and decreasing directions. The slope value of the results the temperature (maximum and minimum) and rainfall variables have a slope value that is greater than the slope value of humidity and wind speed; this means that climate variables that show a significant trend will have a greater slope value than the other variables

Table 3. Summary of the test results: Mann – Kendall trend test and Sen's slope estimator

No	Variable	P Value		Slope	
		Monthly	Annual	Monthly	Annual
1	Rainfall	0.060	0.0222*	0.091	16.85
2	Relative humidity	0.875	0.924	0.0002	0.00741
3	Maximum temperature	0.00158*	0.1245	0.00091	0.00852
4	Wind velocity	0.246	0.393	-0.00024	-0.0025
5	Minimum Temperature	< 0.0001**	0.0296	0.00142	0.013

* = Significance 5 %; ** = Significance 1 %

4. CONCLUSION

The climate variables were analyzed for 36 years in range of 1985-2020. Data is aggregated several data series: monthly and annual. Statistically, correlation test indicates the low relationship maximum temperature to wind velocity and rainfall but other variables have sufficient relationship. In this case, minimum temperature, rainfall, relative humidity and wind speed exert influence on climate condition in Kuningan experimental garden.

The trend result shows suggest positive increasing trends at annual rainfall, monthly maximum temperature and minimum temperature. Moreover, High annual rainfall slope clarifies noticeable a climate variability trend. Climate variability information can be specifically applied at Kuningan experimental garden which as an early warning for water resource planning in Kuningan experimental garden. Therefore, the safe way is a anticipation of high increase rainfall trend in the future during the rainy season. Therefore, increasing rainfall design could also be managed on the flood management and water harvesting during dry season. This analysis needs more specific studies to examine the climate variable especially at extreme events.

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