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Trend Analysis for Annual Rainfall Data in Dili, Timor-Leste using Mann Kendall Method

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ABSTRACT

Rainfall is a key element of the hydrological cycle, therefore detecting trends of rainfall data can be used as information for understanding climate change. The trend of rainfall data in Dili needs to be made to identify changes in the hydrological climate system. The purpose of this study was to determine the rainfall trend in Dili using the Mann-Kendall test. The longest and most complete daily rain data is from stations installed at Dili Airport. Available data is from 1953 - 2017. The rainfall trend obtained can serve to detect possible changes in rainfall in Dili for the coming years. The linear trend shows that the rainfall in Dili tends to decrease every year. According to the Mann-Kendall test, The Aeroporto Dili annual rainfall trends are statistically insignificant. This shows that there is a variation in the daily rainfall in one year, which can be different from other years due to fluctuations in weather and seasons. Although the reduction in rainfall every year is not very significant, it has implications for climate change that affects to water availability. Therefore, the information on trends in annual rainfall data can be used as a reference in dealing with impacts of climate change and water resources available in Dili.

Keywords: Trend analysis, rainfall, climate change, statistical model, Mann-Kendall, water resource.

1. Introduction

Rainfall is a key element of the hydrological cycle. Detecting trends in rainfall data can be used as information to understand climate change. Rainfall changing are actually very difficult to measure, because variability of rainfall based on place, time and on a small scale. Timor Leste is a newly independent country. The meteorological and hydrological data collection program in Timor Leste is uncoordinated yet. During Indonesian rule, East Timor had an excellent network of rainfall gauges and many records have been found (ADB, 2002). At present the metering station is mostly out of function. The Timor rainfall measurement station that is still functioning is a manual rain station that has daily rainfall records. Equipment standardization and data quality control processes are lacking, and there is no systematic process for publishing existing data (ADB, 2004; World Bank, 2018). Despite the constraints of the lack of rainfall data, the trend of rainfall data in Dili needs to be made in order to identify changes in the hydrological climate system.

Research on trend analysis of rain data explains that through long rainfall data a trend can be generated therefore the real changes in rain can be identified over a period of time (Oguntunde et al., 2011; Onyutha et al., 2015). Another study describes the determination of trends in extreme rain that occurs in order to pay more attention to areas that have extreme rain, with the current trend of rainfall data that can also be used as a comparison with projections of future conditions. (González, 2015; Jr et al., 2016; Zhao et al., 2018). Other studies have found that the trend of rain data is made to determine the changes that occur between rain and river discharge, the homogeneity of the trend direction of the rain data and the variation of rain data over time. (Akter et al., 2019; Indarto et al., 2011; Silva et al., 2015).

Several statistical methods are used to generate trend data over a large range. There are two general terms that are often used to distinguish the methods used, namely parametric-test and nonparametric-test. Parametric tests are based on one or more parameters. Linear regression is an example of the parametric-test method (González, 2015). In general, the parametric-test is best used when the variables are normally distributed (Hamed, 2008). However, in general the hydrological time period data is not always normally distributed, in this case a non-parametric test method can be used. In this study, to determine the data trend, the non-parametric Mann Kendall Test method was used. The Mann-Kendall Test to evaluate the presence or absence of trends in the hydrological time period data (Hamed, 2008). Although there are other non-parametric test methods such as the Spearman's Rho Test, the Mann-Kendall Test is considered the most suitable for analyzing climate change or detecting climate discontinuities (Hamed, 2008). Research to utilize this method was explained about compares the relative rankings of data values against time (Silva et al., 2015). In another hand Mann-Kendall Test has been widely used to determine trends or changes in hydrological data. (Zhao et al., 2018) using the Mann-Kendall test to explore the linear trends of relationships between various indices in the annual and seasonal precipitation data in Yellow river basin, China.

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(Onyutha et al., 2015) using Mann-Kendall test to investigating the homogeneity of the rainfall trend directions and determining rainfall trends at Nile river basin, Africa. (Indarto et al., 2011) using Mann-Kendall test to analysing temporal variability of rainfall data in East Java region. (Silva et al., 2015) using Mann-Kendall test and Sen's slope estimator statistical tests to analyse spatial and temporal variability and trends of rainfall and river flow in the Cobres River basin, Portugal. (Rahman et al., 2017) using Mann–Kendall, Spearman's rho tests and ARIMA model to Analysis and prediction of rainfall trends over Bangladesh. The purpose of this study was to determine the rainfall trend in Dili using the Mann-Kendall test. The rainfall trend obtained can serve to detect possible changes in rainfall in Dili for the coming years.

2. Location and Data

Dili is the capital of Timor Leste. The city is located at 8.57ºS & 125.57ºE. Dili has 2 seasons, namely the rainy season which usually occurs in December - May and the dry season, from June to November. The city of Dili is included in the Comoro River Basin. The availability of water comes from surface and ground water. The location of Dili can be seen in Figure 1 (Takeleb et al., 2018).

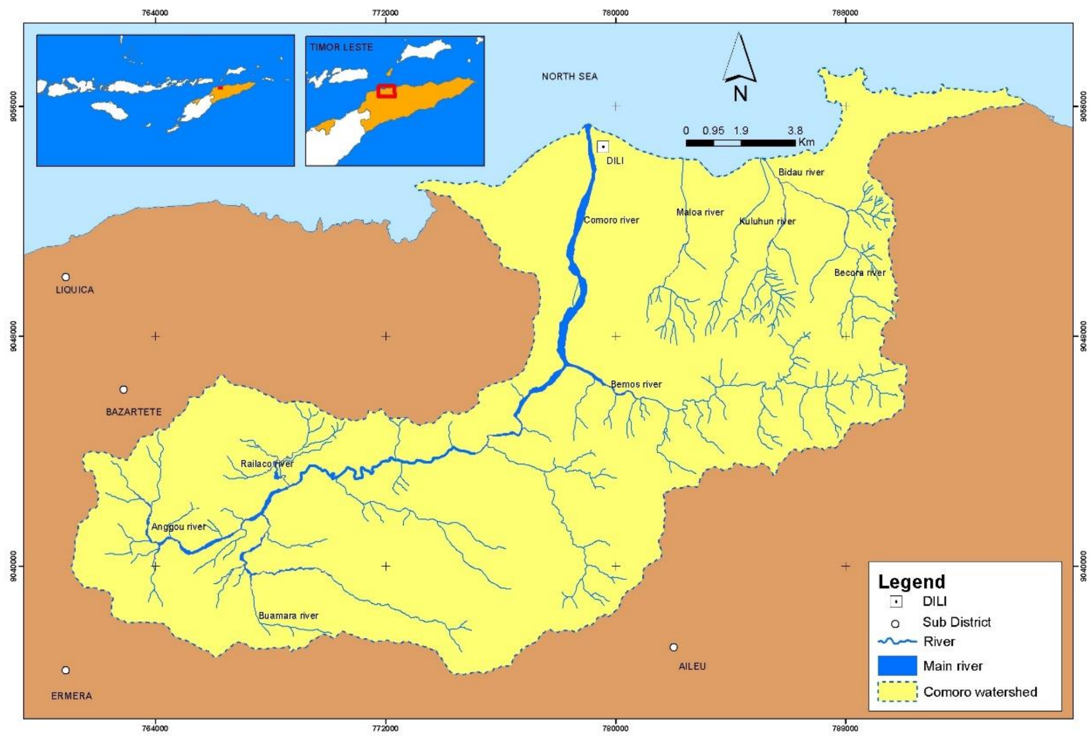

Figure 1. Dili city and Comoro Watershed map

The availability of Dili rainfall and climate data is very limited. Currently there are four daily rain stations operating from 2010 to 2015. The longest and most complete data on daily rainfall is obtained from stations which installed at Comoro airport, where available data are from 1953 - 2017. Daily rainfall data from 2 stations in Dare and Atauro was only recorded from 1953 - 1974 and until now it is no longer operating. The data for 65 years at the Aeroportu Comoro station which will be used in analyzing the rain trend in Dili. The data is not entirely complete because in 1974 and 1975 there was a war between Indonesia & Portugal and the rain data were not recorded. Furthermore, in 2000, 2001 & 2002 years also the rainfall was not recorded because the independence of Timor Leste moment. Therefore, the total data used for this analysis is 60 years of data as in Table 1.

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Table 1. Dili Annual Rainfall Data

Year	Rainfall	Year	Rainfall	Year	Rainfall	Year	Rainfall	Year	Rainfall
1953	913	**1965**	475	**1979**	650	**1991**	510	**2006**	481.2
1954	1248	**1966**	1064	**1980**	990	**1992**	752	**2007**	769.5
1955	2851	**1967**	480	**1981**	949	**1993**	1014	**2008**	1034.2
1956	1216	**1968**	1137	**1982**	523	**1994**	784	**2009**	525.5
1957	836	**1969**	575	**1983**	816	**1995**	1205	**2010**	1716.4
1958	1008	**1970**	859	**1984**	1154	**1996**	976	**2011**	911.8
1959	772	**1971**	898	**1985**	1006	**1997**	628	**2012**	630.7
1960	1097	**1972**	581	**1986**	769	**1998**	1462	**2013**	1045.1
1961	787	**1973**	1495	**1987**	762	**1999**	931	**2014**	703.3
1962	927	**1974**	858	**1988**	1262	**2003**	526.4	**2015**	646.2
1963	862	**1977**	675	**1989**	961	**2004**	1157.9	**2016**	770.3
1964	839	**1978**	985	**1990**	703	**2005**	895.3	**2017**	919.9

3. Metodology

3.1. Data selection and consistency

The data used is annual rainfall data that has been accumulated from monthly rainfall data. Annual rainfall data from 1953 - 2017 were obtained from station with the longest recorded rain data, namely at *Aeroporto* Dili station. This data is provided by the Dili airport in coordination with the Dili Meteorology & Geophysics Directorate. The data is quite complete, there are only gaps of data for 5 years from 1974-1975 and 2000-2002 therefore only 60 years of data are available. The annual rainfall data is then plotted in graphical form and then computed or checked for consistency using the RAPS (Rescaled Adjusted Partial Sums) method. The equation in the RAPS method is as follows (Sri Harto, 2000)

a) Mean
$S_k^* = \sum_{i+1}^{k} (Y_i - \bar{Y})$, with k = 1,2,..,n…..(1)

b) Determine RAPS by devided S_k^* with standard deviation

$S_k^{**} = \frac{S_k^*}{D_y}$ with k = 0,1,2,..,n …......(2)

$D_y^2 = \sum_{i=1}^{n} \frac{(Y_i - \bar{Y})^2}{n}$ ……..(3)

Where Y_i= i^th rainfall data; $\bar{Y}$ = mean rainfall data-I; SD = Standard deviation; n = number of data

c) Consistency test:

$Q = \max_{0 \le k \le n} |S_k^{**}|$ …….(4)

or *range* $R = \max_{0 \le k \le n} S_k^{**} - \min_{0 \le k \le n} S_k^{**}$

Critic value of Q dan R as shown in Table 2 (Sri Harto Br, 2000).

Table 2. Critic Value of Q and R

n	$\frac{Q}{\sqrt{n}}$			$\frac{R}{\sqrt{n}}$		
	90%	**95%**	**99%**	**90%**	**95%**	**99%**
10	1.05	1.14	1.29	1.21	1.28	1.38
20	1.1	1.22	1.42	1.34	1.43	1.6
30	1.12	1.24	1.46	1.4	1.5	1.7
40	1.13	1.26	1.5	1.42	1.53	1.74
50	1.14	1.27	1.52	1.44	1.55	1.78
100	1.17	1.29	1.55	1.5	1.62	1.86
8	1.22	1.36	1.63	1.62	1.75	2

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3.2. Hypothesis & Level Significant (α)

a) The hypothesis is formulated to see the statistical data test whether the data has a trend or not using this Mann-Kendall test.

H_0: Z = normal (no trend)

Hα: Z = not normal (has trend)

b) Level of Confident (α) = 0.05

$Z_{(\alpha/2)} < Z < Z_{(\alpha/2)}$

$(-1.96 < Z < 1.96)$

H_0 rejected if $|Z| > Z(\alpha/2)$

3.3. Autoregressive test

The significance of the available rainfall data has checking out before the trend analysis is done. This test is performed using Auto Regression lag 1 (AR 1) analysis. The purpose of this test is to see whether the data is significant or insignificant. If the test results show that this data series is not significant, then the trend data test can be directly tested using the Mann-Kendall test. If the test results show that the data series is significant, it is necessary to first clean up the effect of autocorrelation which can affect the results of data trends. After cleaning or what is often called pre-whitening is done then the Auto Regression lag 1 test is repeated using a data series that has pass a pre-whitening process.

3.4. Mann-Kendall Test

The Mann-Kendall test is a non-parametric statistical procedure that is well suited for analyzing trends in data over time. The Mann-Kendall Statistic (S) measures the trend in the data. Positive values indicate an increase in constituent concentrations over time, whereas negative values indicate a decrease in constituent concentrations over time. Assessing the trend in the direction of the data, a non-parametric statistical test was performed using the Mann-Kendall Test method. This method is used to identify trends in a data series based on the relative rankings of the time range data. The stages of statistical data testing using the Mann-Kendall test are as follows:

a) Gives an X relative ranking to the annual rainfall data series in the order of the amount of rain.

b) Determine the values of A and B where the ranking results that have been given in the rain data are then compared for each time Xi and Xj (i =1 to N-1 and j = i +1 to N. For i and j as data i^{th} and data j^{th}). The value of A is determined by counting the number of data values that greater than the specified value. The value of B is determined by counting the number of data values that are smaller than the specified value. The results obtained are then added with the value of 1. For A value if $X_j > X_i$ and for B if $X_j < X_i$.

c) Determine the S value

$$s = \sum_{i-1}^{n-1} \sum_{j=i+1}^{n} sgn(x_j - x_i)$$

i =1 to N-1 and j = i +1 to N. For i dan j as data i^{th} and data j^{th}.

d) Determine Z_{MK} value

$$Z_{MK} = \frac{S-1}{\sqrt{V(S)}} for\ S > 0$$

$$Z_{MK} = 0\ for\ S = 0$$

$$Z_{MK} = \frac{S+1}{\sqrt{V(S)}} for\ S < 0$$

Where: $Var(S) = \frac{1}{18}$ (n (n+1) (2n +5))

The value of S that positive or negative interpreted the trend is increase or decrease.

4. Result

4.1. Consistency of Data

Rainfall data from *Aeroportu* Dili station is taken as much as 60 years of data to analyze the rainfall trend in Dili. The first step is to check the consistency of the rain data using the RAPS (Rescaled Adjusted Partial Sums) method. The goal is to know whether the rainfall data is consistent even though there are significant differences in the amount of rainfall data each year. From the available rainfall data, the mean value = 918.657 and Standard Deviation = 376.10.

The value of $\boldsymbol{S_k^*}$ and $\boldsymbol{S_k^{**}}$ obtained from equations (1) and (2) and can be seen in the table below:

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Table 2. S_k^* dan S_k^{**} value

No	Years	R	Sk*	Sk**	No	Years	R	Sk*	Sk**
1	1953	913	-5.657	-0.015	31	1985	1006	87.343	0.233
2	1954	1248	329.343	0.879	32	1986	769	-149.657	-0.399
3	1955	2851	1932.343	5.157	33	1987	762	-156.657	-0.418
4	1956	1216	297.343	0.794	34	1988	1262	343.343	0.916
5	1957	836	-82.657	-0.221	35	1989	961	42.343	0.113
6	1958	1008	89.343	0.238	36	1990	703	-215.657	-0.576
7	1959	772	-146.657	-0.391	37	1991	510	-408.657	-1.091
8	1960	1097	178.343	0.476	38	1992	752	-166.657	-0.445
9	1961	787	-131.657	-0.351	39	1993	1014	95.343	0.254
10	1962	927	8.343	0.022	40	1994	784	-134.657	-0.359
11	1963	862	-56.657	-0.151	41	1995	1205	286.343	0.764
12	1964	839	-79.657	-0.213	42	1996	976	57.343	0.153
13	1965	475	-443.657	-1.184	43	1997	628	-290.657	-0.776
14	1966	1064	145.343	0.388	44	1998	1462	543.343	1.450
15	1967	480	-438.657	-1.171	45	1999	931	12.343	0.033
16	1968	1137	218.343	0.583	46	2003	526.4	-392.257	-1.047
17	1969	575	-343.657	-0.917	47	2004	1157.9	239.243	0.639
18	1970	859	-59.657	-0.159	48	2005	895.3	-23.357	-0.062
19	1971	898	-20.657	-0.055	49	2006	481.2	-437.457	-1.168
20	1972	581	-337.657	-0.901	50	2007	769.5	-149.157	-0.398
21	1973	1495	576.343	1.538	51	2008	1034.2	115.543	0.308
22	1974	858	-60.657	-0.162	52	2009	525.5	-393.157	-1.049
23	1977	675	-243.657	-0.650	53	2010	1716.4	797.743	2.129
24	1978	985	66.343	0.177	54	2011	911.8	12.743	0.034
25	1979	650	-268.657	-0.717	55	2012	630.7	-166.857	-0.445
26	1980	990	71.343	0.190	56	2013	1045.1	126.443	0.337
27	1981	949	30.343	0.081	57	2014	703.3	-215.357	-0.575
28	1982	523	-395.657	-1.056	58	2015	646.2	-272.457	-0.727
29	1983	816	-102.657	-0.274	59	2016	770.3	-148.357	-0.396
30	1984	1154	235.343	0.628	60	2017	919.9	1.243	0.003

The value of Q can be obtained from equation (4) and Q = 5.120. Meanwhile, to obtain a critical value of 90% can be seen from the table of critical value Q with the amount of data (n) = 60 then interpolated and obtained a critical value of 90% = 1.155. To find the critical value as follows:

$$\frac{Q_{critic}}{\sqrt{n}} = Q_{critic90\%}$$

$$Q_{critic} = Q_{critic90\%} * \sqrt{n}$$

$$Q_{critic} = 1.155 * \sqrt{60} = 8.947$$

To find out whether the data is consistent or not, then compare the value of Q with Q_{critic} if Q <Q_{critic} then the station data is consistent. From the calculation, it can be seen that Q = 5.120 < Q_{critic} = 8,947 so it can be stated that the rain data at Dili airport station is consistent.

Based on the rain data, then the statistical value and the annual rainfall fluctuation graph as follows:

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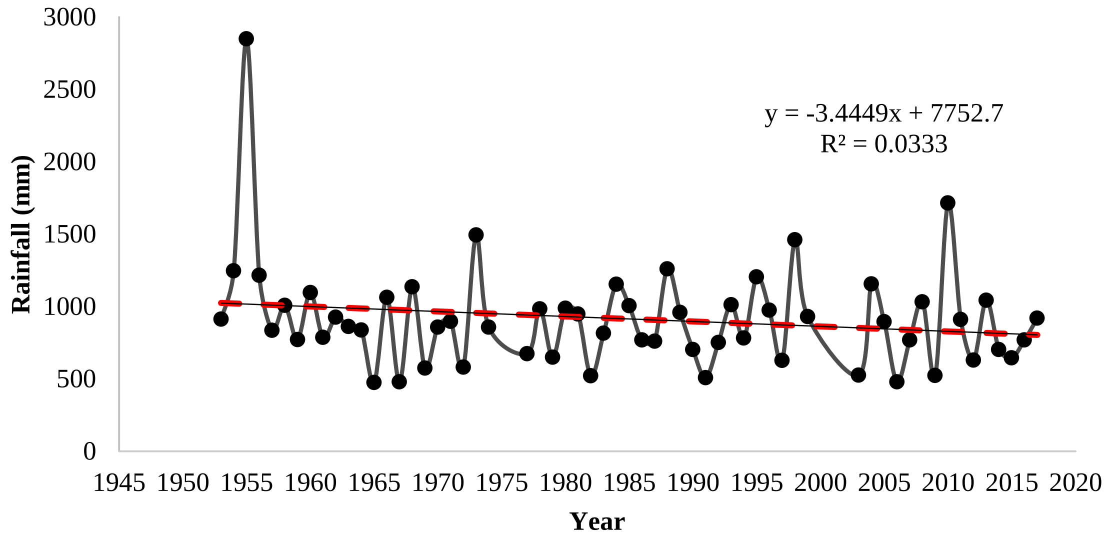

Figure 2. Trendline of Fluctuation Annual Rainfall

Table 3. Statistical Value of Rainfall Data

Max (mm/yr)	Min (mm/yr)	Mean	STDEV	CV
2851	475	918.657	376.10	0.40

The graph of the annual rain fluctuation showing in the existing linear trend has resulted tendency of decreasing rain every year, with a negative trend. From the table of statistical values can be seen that the average annual rainfall is quite large, and the variance value is 0.40 indicating an evenness or similarity (homogeneity) of the rainfall data in Dili.

4.2. Significant Data Test

The significant data test using Autoregression lag 1 (AR 1) is necessarily made before the trend analysis using the Mann Kendall test is carried out. Significant data testing is carried out in order to find a strong relationship between statistical variables. The data is significant or not by comparing the parametric value of the data with the level of confidence or degree of confidence (α) = 0.05. The relationship between X and Y variables is analyzed using Auto Regression lag 1. Variable X is the initial rainfall data and variable Y is lag 1 rain data.

Table 4. Autoregressive Lag 1

No	Years	Y_t	X_{t-1}	No	Years	Y_t	X_{t-1}
		CH	lag 1			CH	lag 1
1	1953	913		31	1985	1006	1154
2	1954	1248	913	32	1986	769	1006
3	1955	2851	1248	33	1987	762	769
4	1956	1216	2851	34	1988	1262	762
5	1957	836	1216	35	1989	961	1262
6	1958	1008	836	36	1990	703	961
7	1959	772	1008	37	1991	510	703
8	1960	1097	772	38	1992	752	510
9	1961	787	1097	39	1993	1014	752

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10	1962	927	787	40	1994	784	1014
11	1963	862	927	41	1995	1205	784
12	1964	839	862	42	1996	976	1205
13	1965	475	839	43	1997	628	976
14	1966	1064	475	44	1998	1462	628
15	1967	480	1064	45	1999	931	1462
16	1968	1137	480	46	2003	526.4	931
17	1969	575	1137	47	2004	1157.9	526.4
18	1970	859	575	48	2005	895.3	1157.9
19	1971	898	859	49	2006	481.2	895.3
20	1972	581	898	50	2007	769.5	481.2
21	1973	1495	581	51	2008	1034.2	769.5
22	1974	858	1495	52	2009	525.5	1034.2
23	1977	675	858	53	2010	1716.4	525.5
24	1978	985	675	54	2011	911.8	1716.4
25	1979	650	985	55	2012	630.7	911.8
26	1980	990	650	56	2013	1045.1	751.8
27	1981	949	990	57	2014	703.3	1045.1
28	1982	523	949	58	2015	646.2	703.3
29	1983	816	523	59	2016	770.3	646.2
30	1984	1154	816	60	2017	919.9	770.3
						0	919.9

The parametric test value of lag 1 data is 0.904, which is greater than the value of the degree of confidence (α) 0.05 so that it can be stated that the interplay between variables in this data is not significant.

The value of the correlation coefficient (r) is also less than 1, which indicates that the variable relationship is not strong.

4.3. Mann Kendall Trend Test

Linear trend that occurs, it shows that the rainfall in the city of Dili tends to decrease every year. However, it needs to be proven by the Mann Kendall Test to assess whether the tendency for the decline to occur is significant or not.

Table 5. Mann Kendall test result

Data	Rainfall	Rank	P	M	Check	Data	Rainfall	Rank	P	M	Check
1953	913	34	26	33	59	1985	1006	43	8	21	29
1954	1248	55	5	53	58	1986	769	19	17	11	28
1955	2851	60	0	57	57	1987	762	18	17	10	27
1956	1216	54	4	52	56	1988	1262	56	2	24	26
1957	836	26	30	25	55	1989	961	39	8	17	25
1958	1008	44	13	41	54	1990	703	15	17	7	24
1959	772	22	32	21	53	1991	510	4	22	1	23
1960	1097	49	8	44	52	1992	752	17	15	7	22
1961	787	24	29	22	51	1993	1014	45	6	15	21
1962	927	36	19	31	50	1994	784	23	11	9	20
1963	862	30	23	26	49	1995	1205	53	2	17	19
1964	839	27	25	23	48	1996	976	40	5	13	18
1965	475	1	47	0	47	1997	628	10	14	3	17
1966	1064	48	8	38	46	1998	1462	57	1	15	16
1967	480	2	45	0	45	1999	931	37	4	11	15
1968	1137	50	7	37	44	2003	526.4	7	12	2	14

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1969	575	8	38	5	43	2004	1157.9	52	1	12	13
1970	859	29	21	21	42	2005	895.3	31	5	7	12
1971	898	32	19	22	41	2006	481.2	3	11	0	11
1972	581	9	35	5	40	2007	769.5	20	6	4	10
1973	1495	58	1	38	39	2008	1034.2	46	2	7	9
1974	858	28	19	19	38	2009	525.5	6	8	0	8
1977	675	14	28	9	37	2010	1716.4	59	0	7	7
1978	985	41	11	25	36	2011	911.8	33	2	4	6
1979	650	13	27	8	35	2012	630.7	11	5	0	5
1980	990	42	10	24	34	2013	1045.1	47	0	4	4
1981	949	38	12	21	33	2014	703.3	16	2	1	3
1982	523	5	30	2	32	2015	646.2	12	2	0	2
1983	816	25	16	15	31	2016	770.3	21	1	0	1
1984	1154	51	5	25	30	2017	919.9	35	0	0	0

Table 6. Rank Sum Test

S	VAR (S)	Z		Critical value (Zc) (α =0,05)	
-172	25416.67	-1.072	1.072	1.96 or -1.96	-1.96 < -1.072 < 1.96

The z value on the Mann Kendall Test is the result of a comparison of the S value (notation) with its variants. The value of S is the result of a reduction in the value of P and M, which is the accumulated rank relatively larger (for P) and smaller (for M) at each data ranking comparison, showing a downward trend. From the results of statistical tests, it is known that the Mann-Kendall Test method shows an insignificant trend in the Dili Rain Station data with a statistical value of z = -1.072.

5. Discussion

Dili's rainfall generally includes into the monsoonal rainfall pattern. This monsoonal rainfall pattern is characterized by one peak of the rainy season (unimodal), between December, January, and February, and has a clear difference between the rainy season and the dry season. Figure 3 shows the pattern of monthly average rainfall in Dili. Based on the temporal distribution, December is the peak of the rainy season for all periods. The peak of the dry season for the period 1953-1974 occurred in September, while for the periods 1977-1999 and 2003-2017 occurred in August.
The trend in rainfall for the annual rainfall is decrease.

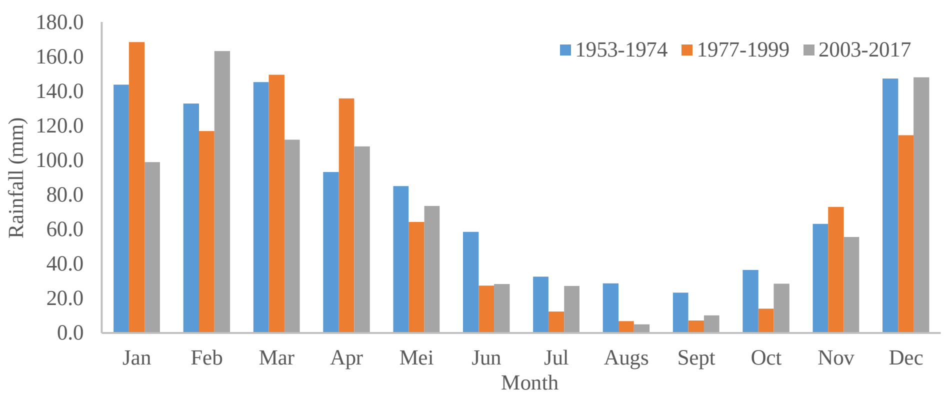

Figure 3. Average monthly rainfall in Dili

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The tendency of the annual rainfall to fall is shown by the regression equation y = -3.4449x + 7752.7 (R^2 = 0.0333). This condition is supported by the results of research conducted by the Australian Bureau of meteorology in 2013 on the rainfall data for the years 1953-2009 at the *Aeroporto* station, Dili which showed a decreasing rain pattern. The *Aeroporto* Dili negative annual and dry season rainfall trends for the period 1952–2009 are statistically significant. The wet season rainfall trend is not statistically significant (Australian Bureau of Meteorology, 2013)

The trend of decreasing annual rainfall is also indicated by the fluctuation of the annual average value. The average annual rainfall in Dili in general shows a decreasing trend and certain years show a decrease, such as around 1955 when El Nino occurred.

According to the Mann-Kendall test, The Dili Airport negative annual rainfall trends for the period 1953–2017 are statistically insignificant. The results of the Runk Sum Test show that the z statistical value is smaller than the specified significant value (α), namely 0.05 or equal to 1.96 (critical value). The data shows an insignificant trend, meaning that the data with large or small rankings are fairly evenly distributed over time. Thus it can be stated that the rain data at Sta. Dili does not show a significant trend. This matter, shows daily variation (daily rise and fall of rain) within a year, which can differ from daily variations in other years (before or after) due to weather and seasonal fluctuations, Annual fluctuation of rainfall in Dili ranges from 400 to 2500 mm. The seasonal cycle of rainfall shows that Dili has a very marked wet season from December to May and a dry season from June to November. The effect of the West Pacific Monsoon is very strong.

Changes in rain patterns will result in a shift in the beginning of the season, both wet and dry. Drought disasters due to a longer dry season threatens land productivity. On the other hand, the rainy season will last a shorter time but with high intensity when compared to normal conditions. This will increase the potential of floods and landslides

The decline in the trend of rain data at Dili Airport is also shows implications for water availability due to fluctuations in rain and climate. The results of this trend in rainfall data are the main reference for the government to prepare for the decrease in water availability due to decreasing rainfall intensity each year. Although the value of reduction is relatively small, it needs to be considered as a warning in the development and management of water resources in Dili against the various existing needs. The government should pay attention to placing rain gauge in several places which is very useful in the process of collecting rain data for the purposes of further rain analysis.

6. Conclusion

The rain data trend test has resulted a decreasing (negative) trend in annual rainfall data at the Aeroporto Dili station. Therefore, it can be concluded that the tendency of rain to occur is not significant and the distribution of rain occurs unevenly in Dili. The implication of this research affects the preparation of the government in anticipating climate change every year which has an impact on decreasing water availability. In further research, it is expected to be able to examine the trend of rain data at other rain stations in the city of Dili or those in the Comoro catchment area.

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