第 49 卷 第 4 期
2022 年 4 月

湖南大学学报（自然科学版）
Journal of Hunan University (Natural Sciences)

Vol. 49 No. 4
April 2022

Open Access Article https://doi.org/10.55463/issn.1674-2974.49.4.27

Detection of Climate Change in the Kedungsoko Irrigation Area – Nganjuk, Indonesia

Olvi Pamadya[1*], Pitojo Tri Juwono[2], Ussy Andawayanti[2], Runi Asmaranto[2]

[1] Doctoral Program at the Department of Water Resources Engineering, Faculty of Engineering, University of Brawijaya, Jl. MT Haryono No 167, Malang, Indonesia

[2] Department of Water Resources, Faculty of Engineering, University of Brawijaya, Jl. MT Haryono No 167 Malang, Indonesia

Abstract: Rainfall is one of the main components in discussing climate where there is a complex process in it. Rainfall has a dynamic characteristic, and it is not fixed along the season period. The change in rainfall intensity has commonly happened. However, if the change has extremely different, it will indicate climate change overall. The rainfall change can impact the agricultural sector because dropped rainfall will affect the crops. Too many rainfalls will cause flooding and rotting plants. However, too little water also causes nutritional deficiency in the crop and causes crop failure. The crop failure in the Kedungsoko Irrigation Area-Nganjuk-Indonesia is due to climate change, such as the extreme rainfall dropping there. In this research, the climate change is mainly related to the season shift for arranging the cropping pattern in the research area. The potency of events like that can reoccur in the future. This research intends to analyze the climate change in the Kedungsuko Irrigation Area statistically. In addition, this research aims to investigate the season shift based on climate change. The methodology uses parametric and non-parametric statistics. Based on the extreme analysis by using the parametric method (F-test and T-test) and non-parametric method (Mann Kendall test), it is obtained the prediction of the extreme rainfall that is likely to happen in the future is in January and December. It is hoped to become the consideration for anticipating the same undesirable event in the Kedungsoko Irrigation Area.

Keywords: climate change, extreme rainfall, parametric test, non-parametric test.

在克东索科灌区检测气候变化 –甘竹，印度尼西亚

摘要：降雨是讨论气候的主要组成部分之一，其中存在复杂的过程。降雨具有动态特征，在季节期间不固定。降雨强度的变化经常发生。但是，如果变化有很大的不同，则表明整体气候变化。降雨量变化会影响农业部门，因为降雨量减少会影响农作物。过多的降雨会导致洪水和植物腐烂。然而，水太少也会导致作物营养不足，导致作物歉收。克东索科灌溉区-甘竹-印度尼西亚的作物歉收是由于气候变化，例如那里的极端降雨量。在本研究中，气候变化主要与研究区种植模式安排的季节变化有关。类似事件的效力可能会在未来再次发生。本研究旨在统计分析克东索科 灌区的气候变化。此外，本研究旨在调查基于气候变化的季节变化。该方法使用参数和非参数统计。基于参数方法（F 检验和吨检验）和非参数方法（曼肯德尔检验）的极端分析，得到未来极可能发生的极端降雨预测为 1 月份和十二月。希望成为在克东索科灌区预见同样不良事件的考虑因素。

关键词：气候变化, 极端降雨, 参数检验，非参数检验。

Received: February 14, 2022 / Revised: March 18, 2022 / Accepted: March 19, 2022 / Published: April 30, 2022
About the authors: Olvi Pamadya, Doctoral Program at the Department of Water Resources Engineering, Faculty of Engineering, University of Brawijaya, Malang, Indonesia; Pitojo Tri Juwono, Ussy Andawayanti, Runi Asmaranto, Department of Water Resources, Faculty of Engineering, University of Brawijaya, Malang, Indonesia
Corresponding author Olvi Pamadya, olvi.pamadya@gmail.com

1. Introduction

Rainfall is one of the very important climates unsure. However, the existence spatially and temporally is still difficult to be predicted. Besides the dynamic characteristic, the involved physical process is also very complex [1]. Rainfall is the climate parameter that has high variability spatially and temporally. Therefore, the analysis of rainfall needs many observation data and is evenly distributed by the log series data [2].

Rainfall also has a big variability in space and time. Rainfall variability is classified into daily, monthly, and yearly types in the time scale. The local factor influences the variation of daily rainfall; however, the variation of monthly rainfall is affected by the land breeze and sea breeze, convection activity, the direction of airflow on the surface, and the variation of mainland and ocean distribution. The variation of yearly rainfall is affected by the behavior of the global atmosphere, tropical cyclones, etc. [3, 4]. One of the important challenges in the third millennium is that rainfall variability impacts climate change due to global warming. New evidence from the up-to-date studies shows that the anthropogenic factor, mainly the very fast industrial development during the last 50 years, has significantly triggered global warming [5, 6].

Climate change is variability that is statistically significant on average and variability to be persistent during a long period (decade or longer). Climate change is caused by internal and external processes or the persistent anthropogenic change from the atmosphere composition or land use. This definition is a reference in detecting the happening of climate change, whether the climate change has happened or only happens the climate variability [7].

Climate change is believed to impact some life aspects, especially the agricultural sector, negatively. It is worried it will cause a new problem for the sustainability of agricultural production, mainly the food crop [5]. The agricultural sector is vulnerable to climate change because it affects the cropping pattern, schedule, production, and product quality [8, 9].

Global climate change is also influencing the climate in Indonesia. It is proved by the increase in rainfall and temperature in the eastern area of Indonesia. The rainfall decreases, and the temperature increases in the western area of Indonesia [10]. Climate change can decrease production and food commodity productivity [11, 12]. One of the agricultural areas impacted by climate change is Nganjuk Regency. The incident of climate change is the season shift that has happened several times in this area by being marked with crop failure. Drought ever hits this area [13], and the flooding incident ever hits this area and causes crop failure. These incidents prove that the agricultural sector is very vulnerable due to the impact of the season shift [14].

The Kedungsoko Irrigation Area in the Nganjuk Regency has a rice field raw area of the tertiary field of 799 ha. It is naturally also threatened due to the season shift. Suppose there is happened crop failure due to the season shift. In that case, it can cause worries about the stability of the foodstuffs, which takes a domino effect on the economic and social system. There are many methods for optimizing agricultural yields. The most accurate method to be carried out now is intensification which means optimizing the available agricultural system.

2. Materials and Method

2.1. Location of Study

The research location is in the Nganjuk Regency, specifically in the Kedungsoko Irrigation Area, Malangsari Village, Sukomoro District, with a rice field raw area is 788 ha. The map of the location is presented in Fig. 1.

Fig. 1 Map of Sukomoro District, Nganjuk Regency

2.2. Parametric Test

The method used for detecting the season shifting is the parametric method like the F test and T-test. The parametric method assumes that a population has or follows a certain distribution. Therefore, a specific parameter is needed in the parametric method, like the average value, deviation standard, and variance of the observed population.

F test can be used for big data samples (N 30) or small samples ($N < 30$). The F test evaluates the variance of the data sample to prove whether there is a difference or not of the variance in one class of data or every variance among data classes. F test is used to simultaneously determine the independent variable's effect on the dependent variable. For example, using the significant level of 5 % (0.05) and the probability < 0.05, it is said that there is a significant effect. However, if the significant value is > 0.05, there is no significant effect between the independent and dependent variables. F test can be used for big data samples (N 30) or small samples ($N < 30$). In addition, the F test evaluates the data sample's variance to prove whether there is a difference or not of the variance in one class of data or every variance among data classes.

The T-test is generally used for evaluating the data sample with a small size (N < 30). The tested data is the average between two groups, the sample average to the population average, and the paired data. The T-test is used for testing each variable partially. If the probability of t value < 0.05, the independent and dependent variables' effect is partial. If the probability of t value > 0.05, there is no significant effect of the independent variable on the dependent variable.

2.3. Non-Parametric Test

Trend analysis using the Mann-Kendall test and non-parametric Sens method is used to estimate the slope of the linear trend. The Mann-Kendall test is a non-parametric test that does not need the normally distributed data. Instead, the non-parametric test analyzes all trends' significance [15]. In this analysis, every observation point is tested about the trend significance with m of the Mann-Kendal test. Then, the trend analysis uses the Makesens Template [15]. Based on the analysis, the monthly and yearly rainfall trends will be obtained due to the significant level of 10%, 5%, and 1%.

The Mann-Kendall test can be applied if the data value of time series-xi can be described with the following model: xi = f(t) + ε, where the function of f(t) is the continuously increasing or decreasing and ε is assumed coming from the same distribution, while the average is 0.

Therefore, it is assumed that the variance is from the constant distribution by time. Then, the hypothesis will be tested as follows: if there is no trend, the H0 is accepted, and if there is a trend of increasing or decreasing, the hypothesis alternative H1 is accepted.

3. Results and Discussion

3.1. The Result of Parametric Test

The data must be classified into two-period groups for the parametric test (F test and T-test). The first-period group is the rainfall from 2001 until 2010, and the second period one is the rainfall from 2011 until 2019. Therefore, the amount of data in the first period is n = 10, and in the second period is n = 9. Therefore, the parametric test is carried out in each rainfall station that is Banaran and Patihan, plus the average of the two rainfall stations that illustrates the condition of the Kedungsoko Irrigation Area overall for 10 days every period for 19 years. The result is presented in Tables 1, 2, and 3 for Banaran, Patihan Rainfall Station, and the average of both of them.

Table 1 Parametric test for Banaran rainfall station

Month	Jan-1	Jan-2	Jan-3	Feb-1	Feb-2	Feb-3	Mar-1	Mar-2	Mar-3
Parameter	**F test**								
Variance P-1	7304.711	2667.656	5433.656	2899.111	2950.322	4399.111	5291.389	2542.322	7058.044
Variance P-2	3056	3400.611	7387.25	2647.028	5941.528	3217.5	1802.944	5144.444	3388.611
n1 - 1	9	9	9	9	9	9	9	9	9
n2 - 1	8	8	8	8	8	8	8	8	8
F calculation	2.390285	0.784464	0.735545	1.095233	0.49656	1.367245	2.93486	0.494188	2.082872
F table	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813
Significance	No	No	No	No	No	No	No	No	No
	T test								
$\bar{P}1 - \bar{P}2$	24.26667	-44.7889	-10.4333	13.55556	-40.4556	35	23.27778	1.677778	42.28889
(n1 -1)S12 + (n2 - 1)S2	90190.4	51213.79	108000.9	47268.22	74085.12	65332	62046.06	64036.46	90631.29
(n1 - 1) + (n2 - 1)	17	17	17	17	17	17	17	17	17
[2] / [3]	5305.318	3012.576	6352.994	2780.484	4357.948	3843.059	3649.768	3766.85	5331.252
(1/n1) + (1/n2)	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111
[4] * [5]	1120.012	635.9882	1341.188	586.991	920.0113	811.3124	770.5066	795.224	1125.487
sqrt [6]	33.46657	25.21881	36.62223	24.2279	30.33169	28.48355	27.758	28.19972	33.54827
T Statistic	0.725102	-1.77601	-0.28489	0.559502	-1.33377	1.22878	0.838597	0.059496	1.260538
T critical	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816
Significance	No	No	No	No	No	No	No	No	No

Month	Apr-1	Apr-2	Apr-3	May-1	May-2	May-3	Jun-1	Jun-2	Jun-3
Parameter	**F test**								
Variance P-1	3310	2821.167	1691.956	564.8889	592.0444	94.98889	144.4	158.3222	185.3444
Variance P-2	2803.778	2800.75	5191.278	4645.944	1458.25	843.5278	2512	89.5	505.4444
n1 - 1	9	9	9	9	9	9	9	9	9
n2 - 1	8	8	8	8	8	8	8	8	8
F calculation	1.18055	1.00729	0.325923	0.121588	0.405997	0.112609	0.057484	1.768963	0.366696
F table	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813
Significance	No	No	No	No	No	No	No	No	No
	T test								
$\bar{P}1 - \bar{P}2$	-10.4444	-1.83333	-36.3556	-24.2222	-15.6	-10.4556	-18.8667	1.1	-11.4778
(n1 -1)S12 + (n2 - 1)S2	52220.22	47796.5	56757.82	42251.56	16994.4	7603.122	21395.6	2140.9	5711.656
(n1 - 1) + (n2 - 1)	17	17	17	17	17	17	17	17	17
[2] / [3]	3071.778	2811.559	3338.695	2485.386	999.6706	447.2425	1258.565	125.9353	335.9797
(1/n1) + (1/n2)	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111
[4] * [5]	648.4864	593.5513	704.8357	524.6925	211.0416	94.41786	265.697	26.58634	70.92906
sqrt [6]	25.4654	24.36291	26.54874	22.90617	14.52727	9.716885	16.30021	5.156194	8.421939
T Statistic	-0.41014	-0.07525	-1.36939	-1.05745	-1.07384	-1.07602	-1.15745	0.213336	-1.36284
T critical	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816
Significance	No	No	No	No	No	No	No	No	No

Month	Jul-1	Jul-2	Jul-3	1-Aug	2-Aug	3-Aug	Sep-1	Sep-2	Sep-3
Parameter	**F test**								
Variance P-1	0	16.72222	0	0	0	0	656.1	739.6	52.9
Variance P-2	40.11111	468.25	326.6944	79	441	0	21.77778	0	2978.028
n1 - 1	9	9	9	9	9	9	9	9	9
n2 - 1	8	8	8	8	8	8	8	8	8
F calculation	0	0.035712	0	0	0	0	30.12704	0	0.017763
F table	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813
Significance	No	No	No	No	No	No	No	No	No
	T test								
$\bar{P}1 - \bar{P}2$	-2.11111	-8.5	-7.22222	-4	-7	0	6.544444	8.6	-18.1444
(n1 -1)S12 + (n2 - 1)S2	320.8889	3896.5	2613.556	632	3528	0	6079.122	6656.4	24300.32
(n1 - 1) + (n2 - 1)	17	17	17	17	17	17	17	17	17
[2] / [3]	18.87582	229.2059	153.7386	37.17647	207.5294	0	357.5954	391.5529	1429.431
(1/n1) + (1/n2)	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111
[4] * [5]	3.984895	48.38791	32.45592	7.848366	43.81176	0	75.49237	82.66118	301.7687
sqrt [6]	1.99622	6.956142	5.69701	2.801494	6.619046	0	8.688634	9.091819	17.37149
T Statistic	-1.05755	-1.22194	-1.26772	-1.42781	-1.05755	0	0.753219	0.945905	-1.0445
T critical	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816
Significance	No	No	No	No	No	No	No	No	No

Month	Oct-1	Oct-2	Oct-3	Nov-1	Nov-2	Nov-3	Dec-1	Dec-2	Dec-3
Parameter	**F test**								
Variance P-1	337.2889	771.7889	1457.333	3178.9	2505.156	4163.822	8445.6	902.7111	3107.378
Variance P-2	1225	0	469.3611	3472.778	1142	4199.5	2363.944	1614.194	6201.611
n1 - 1	9	9	9	9	9	9	9	9	9
n2 - 1	8	8	8	8	8	8	8	8	8
F calculation	0.275338	0	3.10493	0.915377	2.193656	0.991504	3.572673	0.559233	0.50106
F table	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813	3.38813
Significance	No	No	No	No	No	No	**Yes**	No	No
	T test								
$\bar{P}1 - \bar{P}2$	-0.86667	10.7	17.11111	-7.25556	13.26667	10.26667	12.82222	-49.3778	45.71111
(n1 -1)S12 + (n2 - 1)S2	12835.6	6946.1	16870.89	56392.32	31682.4	71070.4	94921.96	21037.96	77579.29
(n1 - 1) + (n2 - 1)	17	17	17	17	17	17	17	17	17
[2] / [3]	755.0353	408.5941	992.4052	3317.195	1863.671	4180.612	5583.644	1237.527	4563.488
(1/n1) + (1/n2)	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111	0.211111
[4] * [5]	159.3963	86.25876	209.5078	700.2968	393.4416	882.5736	1178.769	261.2557	963.4029
sqrt [6]	12.62523	9.287559	14.47438	26.46312	19.83536	29.70814	34.33321	16.1634	31.03873
T Statistic	-0.06865	1.152079	1.182165	-0.27418	0.668839	0.345584	0.373464	-3.05491	1.472712
T critical	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816	2.109816
Significance	No	No	No	No	No	No	No	**Yes**	No

Based on the parametric test above, it can be concluded that there is significant data on the first 10 daily rainfall in December (F test) and the second 10 daily rainfall in December (T-test). So, statistically, there will be found rainfall change in the future.

Table 2 Parametric test for Patihan rainfall station

Month	Jan-1	Jan-2	Jan-3	Feb-1	Feb-2	Feb-3	Mar-1	Mar-2	Mar-3
Parameter	**F test**								
Variance P-1	3668.62	865.43	8568.90	7255.66	5205.07	6421.29	11610.68	6754.67	15192.23
Variance P-2	6228.25	5170.86	8571.61	1476.19	6699.86	2077.00	1418.11	4223.44	3064.78
n_1 - 1	9	9	9	9	9	9	9	9	9
n_2 - 1	8	8	8	8	8	8	8	8	8
F calculation	0.59	0.17	1.00	4.92	0.78	3.09	8.19	1.60	4.96
F table	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39
Significance	No	No	No	**Yes**	No	No	**Yes**	No	**Yes**
	T test								
$\overline{P}_1 - \overline{P}_2$	-61.47	-76.99	-46.41	20.32	-62.09	63.13	15.41	-18.78	52.14
$(n_1-1)S_1^2 + (n_2-1)S_2^2$	82843.60	49155.79	145692.99	77110.46	100444.49	74407.60	115840.99	94579.56	161248.32
$(n_1-1) + (n_2-1)$	17	17	17	17	17	17	17	17	17
[2] / [3]	4873.15	2891.52	8570.18	4535.91	5908.50	4376.92	6814.18	5563.50	9485.20
(1/n1) + (1/n2)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
[4] * [5]	1028.78	610.43	1809.26	957.58	1247.35	924.02	1438.55	1174.52	2002.43
sqrt [6]	32.07	24.71	42.54	30.94	35.32	30.40	37.93	34.27	44.75
T Statistic	-1.92	-3.12	-1.09	0.66	-1.76	2.08	0.41	-0.55	1.17
T critical	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
Significance	No	**Yes**	No	No	No	No	No	No	No

Month	Apr-1	Apr-2	Apr-3	May-1	May-2	May-3	Jun-1	Jun-2	Jun-3
Parameter	**F test**								
Variance P-1	8586.72	3668.68	1735.96	533.34	1047.56	135.12	0.00	3.60	268.10
Variance P-2	1907.00	4263.00	3009.69	3148.75	1244.36	758.44	2388.61	99.44	643.28
n_1 - 1	9	9	9	9	9	9	9	9	9
n_2 - 1	8	8	8	8	8	8	8	8	8
F calculation	4.50	0.86	0.58	0.17	0.84	0.18	0.00	0.04	0.42
F table	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39
Significance	**Yes**	No	No	No	No	No	No	No	No
	T test								
$\overline{P}_1 - \overline{P}_2$	-8.50	-26.97	-38.98	-27.03	-13.11	-16.08	-21.89	-5.18	-9.34
$(n_1-1)S_1^2 + (n_2-1)S_2^2$	92536.50	67122.10	39701.16	29990.10	19382.89	7283.66	19108.89	827.96	7559.12
$(n_1-1) + (n_2-1)$	17	17	17	17	17	17	17	17	17
[2] / [3]	5443.32	3948.36	2335.36	1764.12	1140.17	428.45	1124.05	48.70	444.65
(1/n1) + (1/n2)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
[4] * [5]	1149.15	833.54	493.02	372.43	240.70	90.45	237.30	10.28	93.87
sqrt [6]	33.90	28.87	22.20	19.30	15.51	9.51	15.40	3.21	9.69
T Statistic	-0.25	-0.93	-1.76	-1.40	-0.85	-1.69	-1.42	-1.61	-0.96
T critical	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
Signicance	No	No	No	No	No	No	No	No	No

Month	Jul-1	Jul-2	Jul-3	Aug-1	Aug-2	Aug-3	Sep-1	Sep-2	Sep-3
Parameter	**F test**								
Variance P-1	0.00	558.40	0.00	0.00	6.40	10.00	435.60	722.50	3.60
Variance P-2	4.00	146.78	513.86	135.44	469.44	0.00	18.78	0.00	2628.50
n_1 - 1	9	9	9	9	9	9	9	9	9
n_2 - 1	8	8	8	8	8	8	8	8	8
F calculation	0.00	3.80	0.00	0.00	0.01	0.00	23.20	0.00	0.00
F table	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39
Significance	No	**Yes**	No	No	No	No	**Yes**	No	No
	T test								
$\overline{P}_1 - \overline{P}_2$	-0.67	1.36	-8.89	-5.78	-6.42	1.00	5.16	8.50	-19.07
$(n_1-1)S_1^2 + (n_2-1)S_2^2$	32.00	6199.82	4110.89	1083.56	3813.16	90.00	4070.62	6502.50	21060.40
$(n_1-1) + (n_2-1)$	17	17	17	17	17	17	17	17	17
[2] / [3]	1.88	364.70	241.82	63.74	224.30	5.29	239.45	382.50	1238.85
(1/n1) + (1/n2)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
[4] * [5]	0.40	76.99	51.05	13.46	47.35	1.12	50.55	80.75	261.53
sqrt [6]	0.63	8.77	7.14	3.67	6.88	1.06	7.11	8.99	16.17
T Statistic	-1.06	0.15	-1.24	-1.58	-0.93	0.00	0.73	0.95	-1.18
T critical	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
Significance	No	No	No	No	No	No	No	No	No

Month	Oct-1	Oct-2	Oct-3	Nov-1	Nov-2	Nov-3	Dec-1	Dec-2	Dec-3
Parameter	**F test**								
Variance P-1	763.96	1645.43	1267.60	2926.62	2259.21	2702.00	8771.51	2011.38	6122.10
Variance P-2	860.44	2.00	250.00	1809.25	1566.50	5554.50	2727.36	1913.86	4240.28
n_1 - 1	9	9	9	9	9	9	9	9	9
n_2 - 1	8	8	8	8	8	8	8	8	8
F calculation	0.89	0.00	5.07	1.62	1.44	0.49	3.22	1.05	1.44
F table	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39
Significance	No	No	**Yes**	No	No	No	No	No	No
	T test								
$\overline{P}_1 - \overline{P}_2$	3.02	13.23	16.60	5.13	-10.23	-28.33	1.09	-61.49	16.46
$(n_1-1)S_1^2 + (n_2-1)S_2^2$	13759.16	14824.90	13408.40	40813.60	32864.90	68754.00	100762.49	33413.29	89021.12
$(n_1 - 1) + (n_2 - 1)$	17	17	17	17	17	17	17	17	17
[2] / [3]	809.36	872.05	788.73	2400.80	1933.23	4044.35	5927.21	1965.49	5236.54
(1/n1) + (1/n2)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
[4] * [5]	170.87	184.10	166.51	506.84	408.13	853.81	1251.30	414.94	1105.49
sqrt [6]	13.07	13.57	12.90	22.51	20.20	29.22	35.37	20.37	33.25
T Statistic	0.23	0.98	1.29	0.23	-0.51	-0.97	0.03	-3.02	0.49
T critical	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
Significance	No	No	No	No	No	No	No	**Yes**	No

Based on the parametric test for Patihan Rainfall Station, it can be concluded that there is significant data of the first 10 daily rainfall in February, March, April, September, the second 10 daily rainfall in July, the third 10 daily rainfall in March and October (F test), and the second 10 daily rainfall on January and December (T-test).

So, statistically, the rainfall change in the future will be found in the times that have a significant probability.

Table 3 Parametric test for Kedungsoko irrigation area

Month	Jan-1	Jan-2	Jan-3	Feb-1	Feb-2	Feb-3	Mar-1	Mar-2	Mar-3
Parameter	**F test**								
Variance P-1	4092.04	1484.82	4315.73	3534.14	2722.97	4430.38	6980.04	2640.19	8206.25
Variance P-2	4365.81	3971.55	7335.63	1878.49	5970.76	2521.81	1566.59	4081.25	2917.19
n_1 - 1	9	9	9	9	9	9	9	9	9
n_2 - 1	8	8	8	8	8	8	8	8	8
F calculation	0.94	0.37	0.59	1.88	0.46	1.76	4.46	0.65	2.81
F table	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39
Significance	No	No	No	No	No	No	**Yes**	No	No
Month	**Jan-1**	**Jan-2**	**Jan-3**	**Feb-1**	**Feb-2**	**Feb-3**	**Mar-1**	**Mar-2**	**Mar-3**
	T test								
$\overline{P}_1 - \overline{P}_2$	-18.60	-63.49	-28.42	16.94	-51.27	49.07	19.34	-8.55	47.22
$(n_1-1)S_1^2 + (n_2-1)S_2^2$	71754.90	45135.79	97526.66	46835.11	72272.78	60047.90	75353.12	56411.73	97193.73
$(n_1 - 1) + (n_2 - 1)$	17	17	17	17	17	17	17	17	17
[2] / [3]	4220.88	2655.05	5736.86	2755.01	4251.34	3532.23	4432.54	3318.34	5717.28
(1/n1) + (1/n2)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
[4] * [5]	891.07	560.51	1211.12	581.61	897.51	745.69	935.76	700.54	1206.98
sqrt [6]	29.85	23.68	34.80	24.12	29.96	27.31	30.59	26.47	34.74
T Statistic	-0.62	-2.68	-0.82	0.70	-1.71	1.80	0.63	-0.32	1.36
T critical	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
Significance	No	**Yes**	No	No	No	No	No	No	No

Month	Apr-1	Apr-2	Apr-3	May-1	May-2	May-3	Jun-1	Jun-2	Jun-3
Parameter	**F test**								
Variance P-1	5029.35	2819.16	1634.72	446.34	776.40	66.49	36.10	39.78	224.62
Variance P-2	2212.51	3258.75	3610.13	3651.32	1272.34	712.94	2433.82	93.11	466.67
n_1 - 1	9	9	9	9	9	9	9	9	9
n_2 - 1	8	8	8	8	8	8	8	8	8
F calculation	2.27	0.87	0.45	0.12	0.61	0.09	0.01	0.43	0.48
F table	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39
Significance	No	No	No	No	No	No	No	No	No
	T test								
$\overline{P}_1 - \overline{P}_2$	-9.47	-14.40	-37.67	-25.63	-14.36	-13.27	-20.38	-2.04	-10.41
$(n_1-1)S_1^2 + (n_2-1)S_2^2$	62964.18	51442.40	43593.50	33227.58	17166.32	6301.90	19795.46	1102.91	5754.99
$(n_1 - 1) + (n_2 - 1)$	17	17	17	17	17	17	17	17	17
[2] / [3]	3703.78	3026.02	2564.32	1954.56	1009.78	370.70	1164.44	64.88	338.53
(1/n1) + (1/n2)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
[4] * [5]	781.91	638.83	541.36	412.63	213.18	78.26	245.83	13.70	71.47
sqrt [6]	27.96	25.28	23.27	20.31	14.60	8.85	15.68	3.70	8.45
T Statistic	-0.34	-0.57	-1.62	-1.26	-0.98	-1.50	-1.30	-0.55	-1.23
T critical	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
Significance	No	No	No	No	No	No	No	No	No

Month	Jul-1	Jul-2	Jul-3	Aug-1	Aug-2	Aug-3	Sep-1	Sep-2	Sep-3
Parameter	**F test**								
VarianceP-1	0.00	137.61	0.00	0.00	1.60	2.50	540.23	731.03	21.03
Variacen P-2	17.36	283.38	414.78	103.11	455.11	0.00	20.25	0.00	2800.03
n_1 - 1	9	9	9	9	9	9	9	9	9
n_2 - 1	8	8	8	8	8	8	8	8	8
F calculation	0.00	0.49	0.00	0.00	0.00	0.00	26.68	0.00	0.01
F table	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39
Significance	No	No	No	No	No	No	Yes	No	No
	T test								
$\overline{P}_1 - \overline{P}_2$	-1.39	-3.57	-8.06	-4.89	-6.71	0.50	5.85	8.55	-18.61
$(n_1 -1)S_1^2 + (n_2 - 1)S_2^2$	138.89	3505.58	3318.22	824.89	3655.29	22.50	5024.03	6579.23	22589.45
$(n_1 - 1) + (n_2 - 1)$	17	17	17	17	17	17	17	17	17
[2] / [3]	8.17	206.21	195.19	48.52	215.02	1.32	295.53	387.01	1328.79
(1/n1) + (1/n2)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
[4] * [5]	1.72	43.53	41.21	10.24	45.39	0.28	62.39	81.70	280.52
sqrt [6]	1.31	6.60	6.42	3.20	6.74	0.53	7.90	9.04	16.75
T Statistic	-1.06	-0.54	-1.25	-1.53	-1.00	0.00	0.74	0.95	-1.11
T critical	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
Significance	No	No	No	No	No	No	No	No	No

Month	Oct-1	Oct-2	Oct-3	Nov-1	Nov-2	Nov-3	Dec-1	Dec-2	Dec-3
Parameter	**F test**								
Variance P-1	400.40	1165.62	1348.96	2986.53	2117.11	3006.62	8090.71	1059.71	3535.68
Variance P-2	1034.69	0.50	316.78	2522.05	1262.38	4712.19	2281.78	1658.63	5110.00
n_1 - 1	9	9	9	9	9	9	9	9	9
n_2 - 1	8	8	8	8	8	8	8	8	8
F calculation	0.39	0.00	4.26	1.18	1.68	0.64	3.55	0.64	0.69
F table	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39	3.39
Significance	No	No	**Yes**	No	No	No	**Yes**	No	No
	T test								
$\overline{P}_1 - \overline{P}_2$	1.08	11.97	16.86	-1.06	1.52	-9.03	6.96	-55.43	31.08
$(n_1 -1)S_1^2 + (n_2 - 1)S_2^2$	11881.16	10494.60	14674.82	47055.11	29153.03	64757.10	91070.62	22806.40	72701.13
$(n_1 - 1) + (n_2 - 1)$	17	17	17	17	17	17	17	17	17
[2] / [3]	698.89	617.33	863.22	2767.95	1714.88	3809.24	5357.10	1341.55	4276.54
(1/n1) + (1/n2)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
[4] * [5]	147.54	130.33	182.24	584.34	362.03	804.17	1130.94	283.22	902.82
sqrt [6]	12.15	11.42	13.50	24.17	19.03	28.36	33.63	16.83	30.05
T Statistic	0.09	1.05	1.25	-0.04	0.08	-0.32	0.21	-3.29	1.03
T critical	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
Significance	No	No	No	No	No	No	No	**Yes**	No

Based on the parametric test for Kedungsoko Irrigation Area, it can be concluded that there is significant data of the first 10 daily rainfall in March (F test) and the second 10 daily rainfall in January and December (T-test). So, statistically, the rainfall change in the future will be found in the times that have a significant probability.

3.2. Result of Non-Parametric Test

The steps of analyzing by using the Non-Parametric Test (Mann-Kendall Test) in this research are as follows:

1. To classify the data distribution:

The data distribution used in this research is to analyze the Mann Kendall Test for 10 days of rainfall from 2001 until 2019 in each rainfall station and the arithmetic average of the two rainfall stations. The period is due to the day classification of the cropping pattern calendar per-10 daily.

2. To analyze the Mann Kendall Test.
3. To evaluate the hypothesis and to conclude it.

The results are presented in Tables 4, 5, and 6.

Table 4 Result of the Mann-Kendall test in the Banaran rainfall station

Month	**January**			**February**			**March**		
Period	Jan-1	Jan-2	Jan-3	Feb-1	Feb-2	Feb-3	Mar-1	Mar-2	Mar-3
Z	-0.770	2.275	-0.070	-0.210	1.295	-0.600	-0.040	0.035	-1.260
Q	-1.71	5.545	-0.07	5	5	-2.33	0	0.471	-4.5
Significance	-	-	Yes	-	-	-	-	-	-

Month	**April**			**May**			**June**		
Period	Apr-1	Apr-2	Apr-3	May-1	May-2	May-3	Jun-1	Jun-2	Jun-3
Z	-0.210	0.000	1.614	0.288	0.074	0.743	0.729	-0.936	1.708
Q	-0.25	0	2.8	0	0	0	0	0	0
Significance	-	-	-	-	-	-	-	-	-

Month	**July**			**August**			**September**		
Period	Jul-1	Jul-2	Jul-3	Aug-1	Aug-2	Aug-3	Sep-1	Sep-2	Sep-3
Z	0.456	0.455	1.779	1.458	1.004	0.000	0.663	0.000	1.334
Q	0	0	0	0	0	0	0	0	0
Significance	-	-	-	-	-	-	-	-	-

Month	**October**			**November**			**December**		
Period	Oct-1	Oct-2	Oct-3	Nov-1	Nov-2	Nov-3	Dec-1	Dec-2	Dec-3
Z	-0.247	-1.445	-0.685	-0.283	-0.283	-0.666	-0.387	1.329	-2.947
Q	0	0	0	0	0	-2.25	-0.58	2.167	-5.64
Significance	-	-	-	-	-	-	-	-	Yes

In the Banaran Rainfall Station, the significant trend increase happens in January's second 10 daily periods. On the other hand, the significant trend decreasing happens in the third 10 daily periods in December.

Table 5 Result of the Mann-Kendall test in the Patihan rainfall station

Month	January			February			March		
Period	Jan-1	Jan-2	Jan-3	Feb-1	Feb-2	Feb-3	Mar-1	Mar-2	Mar-3
Z	2.299	2.77	1.715	0.07	2.345	0.98	0.105	1.227	0
Q	4.875	6.133	6.385	7	7	-5.22	1	3.4	0
Significance	Yes	Yes	-	-	Yes	-	-	-	-

Month	April			May			June		
Period	Apr-1	Apr-2	Apr-3	May-1	May-2	May-3	Jun-1	Jun-2	Jun-3
Z	0.736	1.584	1.838	0.266	0.979	1.724	1.83	0.991	0.773
Q	3	2.4	3.429	0	0	0	0	0	0
Significance	-	-	-	-	-	-	-	-	-

Month	July			August			September		
Period	Jul-1	Jul-2	Jul-3	Aug-1	Aug-2	Aug-3	Sep-1	Sep-2	Sep-3
Z	0.456	0.299	1.779	1.458	0.795	0	0.663	0	1.445
Q	0	0	0	0	0	0	0	0	0
Significance	-	-	-	-	-	-	-	-	-

Month	October			November			December		
Period	Oct-1	Oct-2	Oct-3	Nov-1	Nov-2	Nov-3	Dec-1	Dec-2	Dec-3
Z	-0.35	-0.25	-0.35	0.948	0.948	0.599	0.35	2.358	-0.46
Q	0	0	0	0	0	1.333	1.063	5.125	-2.09
Significance	-	-	-	-	-	-	-	Yes	-

In the Patihan Rainfall Station, the significant trend increase happened in the first 10 daily periods in January and the second 10 daily periods in February; the significant decrease trend happened in the second 10 daily periods in December.

Table 6 Result of the Mann-Kendall test for Kedungsoko irrigation area

Month	January			February			March		
Period	Jan-1	Jan-2	Jan-3	Feb-1	Feb-2	Feb-3	Mar-1	Mar-2	Mar-3
Z	0.385	2.696	0.63	0.07	1.399	-1.23	0.035	0.77	-0.98
Q	1.25	5.65	2.583	4.75	4.75	-2.5	0.333	2.056	-2.88
Significance	-	Yes	-	-	-	-	-	-	-

Bulan	April			May			June		
Period	Apr-1	Apr-2	Apr-3	May-1	May-2	May-3	Jun-1	Jun-2	Jun-3
Z	0.21	0.7	2.032	-0.07	0.183	1.003	1.025	-0.81	1.708
Q	0.688	1.571	3.75	0	0	0	0	0	0
Significance	-	-	Yes	-	-	-	-	-	-

Month	July			August			September		
Period	Jul-1	Jul-2	Jul-3	Aug-1	Aug-2	Aug-3	Sep-1	Sep-2	Sep-3
Z	0.456	0	1.779	1.458	0.795	0	0.663	0	1.445
Q	0	0	0	0	0	0	0	0	0
Significance	-	-	-	-	-	-	-	-	-

Month	October			November			December		
Period	Oct-1	Oct-2	Oct-3	Nov-1	Nov-2	Nov-3	Dec-1	Dec-2	Dec-3
Z	-0.35	-0.77	-0.61	0.14	0.14	-0.42	0.105	1.785	-1.86
Q	0	0	0	0	0.077	-1	0.05	3.769	-3.17
Significance	-	-	-	-	-	-	-	-	-

In the Kedungsoko Irrigation Area, the significant trend increasing happened in the second 10 daily periods in January and the third 10 daily periods in April; the significant trend decreasing happened in the third 10 daily periods in April.

Table 7 presents the recapitulation of the parametric and non-parametric tests.

Table 7 Recapitulation of parametric and non-parametric test

No.	Significance of Parametric Test						Significance of Non Parametric Test		
	F test			T test			Mann Kendall Test		
	Banaran	Patihan	DI Kedungsoko	Banaran	Patihan	DI Kedungsoko	Banaran	Patihan	DI Kedungsoko
1	Dec 1	Feb 1	Mar 1	Dec 2	Jan 2	Jan 2	Jan 2	Jan 1	Jan 2
2		Mar 1			Dec 2	Dec 2	Dec 3	Jan 2	Apr 3
3		Apr 1						Feb 2	
4		Sep 1						Dec 2	
5		Jul 2							
6		Mar 3							
7		Oct 3							

Based on the parametric and non-parametric test in the study location, it can be concluded as follow:

1. There are many significances in the Patihan rainfall station by the F test and Mann Kendall test; it is due to the manual recording data that has the possibility of human error.
2. The significance is that the same pattern has happened in the Banaran rainfall station and the average of Patihan and Banaran rainfall stations.

4. Conclusion

Generally, climate change is related to El Nino and La Nina. However, the specific aim of climate change investigation in this research is to cover the arrangement of irrigation cropping patterns, so the climate change analysis mainly relates to the season shift.

For example, in the Kedungsoko Irrigation Area, the significant trend increasing happened in the second 10 daily periods in January and the third 10 daily periods in April; the significant trend decreasing happened in the third 10 daily periods in April.

Based on the analysis above, there is a significant frequency that often happens in January and December (6 times). Therefore, it can be concluded that based on the climate change analysis in the Kedungsoko Irrigation Area, statistically, the rainfall is most likely significant to happen in January and December in the future. The big rainfall will cause flooding in the Kedungsoko Irrigation area. Therefore, it is necessary to carry out the anticipated strategy for preventing flooding, remembering that climate change can impact the decreasing production and food commodity productivity. One of the agricultural areas impacted by climate change is Nganjuk Regency. The incident of climate change is the season shift that has happened several times in this area by being marked with crop failure.

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