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# Effect of Climate Change on The Availability of River Water in The Village Kranji District Pekalongan

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## Abstract

Water is an important need in human life which is a natural resource which must be maintained availability. Changes in the land usage and weather can cause changes in the condition of water sources. These changes can affect the availability of water. Currently the river in Kranji Village, Kedungwuni Timur District, Pekalongan Regency, has decreased in quantity. If efforts to protect and repair the springs are not carried out, it can lead to the lost of water source. To better understand the problem of water availability in Kranji Village, East Kedungwuni District, Pekalongan Regency, it is necessary to conduct research that aims to determine the condition of water availability. The research was conducted by collecting data and information that can be used in the analysis of water availability. The data obtained in the form of secondary data, namely data from BMKG. The data were then be analyzed with the influence of climate change. The results showed that the rainfall in the Kranji Village area from 2011-2016 experienced fluctuations in regional rainfall. In 2017-2020 the rainfall rate in the region decreased to 91.8 mm. Design rainfall data in the Kranji Village area from 2011-2020 has an average Log X of 1.972. The amount of surface water has increased to 19% in the 10th year, reached 28.5% in the 15th year and reached 39% in the 20th year which were generated from the 2011-2020 study. Due to climate change, the mainstay flood discharge from runoff is estimated to decrease drastically, as well as rainwater that will seep into groundwater.



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## INTRODUCTION

Several springs which are now the source of water for Local Drink Water Company (*Perusahaan Daerah Air Minum*, PDAM) Pekalongan Regency, one of which is river water in Kranji Village, Kedungwuni Timur District, Pekalongan Regency, has decreased in quantity and quality. Preliminary observation data from BMKG indicate that the flow rate of water in river water has decreased by up to 60% compared to the initial state. The problem of water availability vulnerability in Kranji Village is indicated by a significant decrease in river water discharge discharge. The decrease may lead to the shortage of clean water and drinking water for community consumption in Kranji village. If there is no effort to protect and repair water sources, it is certain that this decrease in discharge will continue until it reaches a critical condition, where there is no longer water source that can be taken.

Based on the 2007 Intergovernmental Panel Climate change (IPCC) Report, it is stated that climate change is characterized by changes in several climate parameters or events, including: (a) changes in the earth's surface temperature, (b) changes in rainfall, (c) changes in extreme weather events, (d) changes in cover ice/snow, and (e) changes in sea level (Rejekiningrum, 2014). Analysis of climate change is important to be carried out to investigate the magnitude of the impact resulting from climate change on the availability of natural resources. As an example , a study conducted by World Wide Fund for Nature (WWF) ((Hansen et al., 2012) showed that in the last 100 year period, there has been an increase in the average annual temperature of up to 0.72-3.92°C accompanied by a decrease in rain precipitation of up to 2-3% in Indonesia. The study also showed that in the southern part of Indonesia has been a shift in the rainy season more than one month later with the increase of rainfall intensity up to 10% in the rainy season and a 75% decrease in the intensity of rainfall in the dry season.

The problem of vulnerability river water in Kranji Village can be affected by the change. In order to understand this problem, a preliminary study on the condition of water sources is needed. A preliminary study is carried out by collecting adequate information on the condition of existing water sources and infrastructure for the provision of clean water / water drinking water by PDAM. The information was obtained from secondary data, from BMKG Pekalongan Regency.

## METHOD

This research was conducted to collect data and information regarding the condition of existing water sources and infrastructure for the provision of clean water/drinking water by PDAM. The information was obtained from secondary data, namely data from BMKG. The research stages were literature and preliminary studies, analysis of climate change consisting of the analysis of rainfall data and analysis, surface flow supply

## RESULTS AND DISCUSSION

### 1. Rain Data Analysis

Rain data analysis was used to analyze daily rainfall data to estimate the maximum daily rainfall with a certain return period (McCarthy et al., 2001). The maximum daily rainfall data with a certain return period were then used to estimate the magnitude of the planned flood. The magnitude of the design flood was used to estimate the amount of flood discharge in the river.

In Table 1 shows the data of the watershed in the Kedungwuni Timur District, Pekalongan Regency by taking one data for each village. It is shown that the area of the river flow in Kranji village has an area of 33.85 $km^2$

**Table 1.** The area of the watershed in the East Kedungwuni District, East Pekalongan Regency.

| No | Nama Watershed Area | Area ($km^2$) |
|---|---|---|
| 1 | Kranji | 33.85 |
| 2 | Prawasan | 18.78 |
| 3 | Sidodadi | 28.24 |
| 4 | Rogobayan | 17.39 |
| 5 | Capgawen | 23.73 |
| 6 | Gembong | 34.54 |
| 7 | Amboekembang | 21.63 |
| 8 | Paesan | 25.80 |
| 9 | Surobayan | 24.21 |
| 10 | Tangkil | 13.54 |

**2. Maximum Daily Rain**

The rain data used were the data for recording daily rain height for the last 10 years from several rain recording stations located in the study area. The data were then analyzed to obtain the maximum daily rainfall that represents the area of each watershed. To obtain the amount of regional rainfall, the Thiessen Polygon Method was used, where the location was plotted on a scale map.

**3. Design Rain**

Design rain is the maximum daily rainfall that is expected to occur only once in a certain period of time, for example 5 years or 10 years. Design rain was obtained based on statistical analysis of the maximum daily rainfall data representing the area of each watershed (Soewarno, 1991). Rain data analysis is usually used Gumbell probability distribution or Log-Pearson Type III probability distribution. In this study only the Log-Pearson Type III probability distribution was used, because since various applications this method usually gives good results. In Table 2, the maximum daily rainfall data were generated and Table 3 is the design rainfall calculation.

**Table 2.** Maximum daily rainfall data for Kranji Village, Kedungwuni District, Pekalongan Regency

| Year | Daily Weather (mm) | Thiesen Koef. | Reinfall Region (mm) |
|---|---|---|---|
| 2011 | 115 | 0.2000 | 82.7 |
| 2012 | 175 | 0.2000 | 89.7 |
| 2013 | 133 | 0.2000 | 80.6 |
| 2014 | 69 | 0.2000 | 85.3 |
| 2015 | 117 | 0.2000 | 122.2 |
| 2016 | 108 | 0.2000 | 125.2 |
| 2017 | 77 | 0.2000 | 96.9 |
| 2018 | 88 | 0.2000 | 95.6 |
| 2019 | 113 | 0.2000 | 78.8 |
| 2020 | 115 | 0.2000 | 91.8 |

The maximum daily rainfall data in Table 2 in the Kranji Village area, Kedungwuni District, Pekalongan Regency produces rainfall data, thiesen coefficient, and regional rainfall from 2011 to 2020. The rainfall from 2011-2020 experiences changes up and down in rainfall rates. rain. The value of the Thiesen coefficient is 0.2000. Rainfall in the Kranji Village area, Kedungwuni Timur District, Pekalongan Regency from 2011-2016 experienced fluctuations in regional rainfall figures. However, in 2017-2020 the rainfall rate in the region decreased to 91.8 mm. From the maximum rainfall data for 2011-2020, it can be seen that the availability of river water in Kranji Village, Kedungwuni District, Pekalongan Regency has decreased, resulting in the reduced water availability in the village.

**Table 3.** Design rainfall data in the Kranji Village area, Kedungwuni District, Pekalongan Regency

| No | Year | Xi (mm/day) | Log Xi | (Log Xi – Log X)$^2$ | (Log Xi – Log X)$^2$ |
|---|---|---|---|---|---|
| 1 | 2011 | 82.7 | 1.9175 | 0.0029 | -0.0002 |
| 2 | 2012 | 89.7 | 1.9526 | 0.0004 | 0.0000 |
| 3 | 2013 | 80.6 | 1.9061 | 0.0043 | -0.0003 |
| 4 | 2014 | 85.3 | 1.9309 | 0.0017 | -0.0001 |
| 5 | 2015 | 122.2 | 2.0869 | 0.0133 | 0.0015 |
| 6 | 2016 | 125.2 | 2.0974 | 0.0158 | 0.0020 |
| 7 | 2017 | 96.9 | 1.9863 | 0.0002 | 0.0000 |
| 8 | 2018 | 95.6 | 1.9805 | 0.0001 | 0.0000 |
| 9 | 2019 | 78.8 | 1.8963 | 0.0057 | -0.0004 |
| 10 | 2020 | 91.8 | 1.9626 | 0.0001 | 0.0000 |
| Total | | 948.5 | 19.717 | 0.04442 | 0.00257 |
| Average Log Xi = Log X | | | 1.972 | | |
| Coefficent of Asymmetry Log, Cs = | | | 1.031 | | |
| Standart Deviation Log, s log X = | | | 0.070 | | |

| No | Repeat Period (T) (year) | P (%) | K | $S_{kog\ x}$ | K*( $S_{kog\ x}$) | Log X average | Log X$_r$ | X$_r$ (mm/day) |
|---|---|---|---|---|---|---|---|---|
| [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] |
| 1 | 1.01 | 99.0 | -1.5666 | 0.070 | 0.1101 | 1.972 | 1.8617 | 72.72 |
| 2 | 2 | 50 | -0.1689 | 0.070 | -0.0119 | 1.972 | 1.9598 | 91.17 |
| 3 | 5 | 20 | 0.7540 | 0.070 | 0.0530 | 1.972 | 2.0247 | 105.85 |
| 4 | 10 | 10 | 1.3403 | 0.070 | 0.0942 | 1.972 | 2.0659 | 116.38 |
| 5 | 25 | 4 | 2.0317 | 0.070 | 0.1427 | 1.972 | 2.1144 | 130.15 |
| 6 | 50 | 2 | 2.5552 | 0.070 | 0.1795 | 1.972 | 2.1512 | 141.65 |
| 7 | 100 | 1 | 3.0419 | 0.070 | 0.2137 | 1.972 | 2.1854 | 153.25 |
| 8 | 200 | 0.5 | 3.5153 | 0.070 | 0.2470 | 1.972 | 2.2187 | 165.45 |
| 9 | 1000 | 0.1 | 4.5829 | 0.070 | 0.3219 | 1.972 | 2.2937 | 196.63 |

Description:
[2] = repeat peiode (year)
[3] = probability (%)
[4] = frequencyfactor K (Log-person III table )
[5] = logarithmic standard deviation
[6] = [4] * [5]
[7] = logarithmic mean value
[8] = [6] + [7]
[9] = Antilog [8]

From Table 3, the design rainfall data in the area, Kranji Village Kedungwuni District, Pekalongan *Regency* from 2011-2020 has an average Log X of 1.972. The asymmetry coefficient of Log, Cs is 1.031 and the standard deviation of Log, s log X is 0.070.

**4. Potential Surface Flow Surface**

Run off is rainwater that falls and flows on the surface and enters the river into a river flow. Therefore the flow of the river comes from surface run off with the interflow is the flow of river water seepage from the ground. The combination of *surface run off* and *interflow is* referred to *direct run off*. In rivers, the *direct run off* mixes with the base flow from the spring *(base flow*), so that the river discharge will be calculated as the total amount between *direct run off* and *base flow*. The run of that analysed in this work was surface runoff which is the largest flow caused by design rain with a certain return period, resulting in a design flood discharge. This design flood discharge can later be used as a basis for designing river protection buildings or other buildings around the river that are affected by river flow.

**5. Potential of River Water for Clean Water in Kranji Village**

To *estimate* the availability of surface water as a water source, it can be done by estimating the magnitude of the river's mainstay discharge (Rahmawati & Noerhayati, 2015). The river mainstay discharge is the minimum discharge that is estimated to always exist (flow) in the river with a certain level of confidence which is basically obtained from statistical analysis of daily rain data and the condition of the relevant watershed (Muhammed et al., 2004).

The mainstay river discharge can be analyzed using the NRECA method or the method developed by FJ Mock based on the condition of rivers in Indonesia. In this study, the FJ Mock method was used. The data used to analyze the mainstay discharge with the FJ Mock method are daily rainfall data, the number of rainy days per month, evapotranspiration data which is usually analyzed by the Penmann method, data on watershed area and land cover conditions.

The amount of evapotranspiration was analyzed by the Penmann method. The data needed for evapotranspiration analysis required for evapotranspiration analysis using the method Penmannare data on daily average temperature, air humidity, average hours of sunshine, and other data so that the daily evapotranspiration is obtained. The evapotranspiration data is then used for mainstay discharge analysis as well as the amount of infiltration that will become groundwater reserves. Other watersheds and subsequent years were analyzed to obtain the magnitude of the mainstay discharge and the volume of incoming water as groundwater reserves each year from 2011 to 2020. In Table 3, data are produced on the mainstay discharge and the volume of river surface water in Kranji village in 2001-2021.

**Table 4.** Discharge and volume of river surface water in Kranji Village in 2011-2022

| Year | Mainstay discharge ($m^3$/second) | Water surface volume (x $10^9$ $m^3$) |
|---|---|---|
| 2011 | 136.30 | 145.64 |
| 2012 | 4.30 | 4.59 |
| 2013 | 133.71 | 4.22 |
| 2014 | 137.07 | 4.32 |
| 2015 | 149.45 | 4.71 |
| 2016 | 145.82 | 4.60 |
| 2017 | 146.05 | 4.61 |
| 2018 | 246.12 | 7.76 |
| 2019 | 174.40 | 155.58 |
| 2020 | 5.50 | 4.91 |

In 2011 the mainstay discharge was 136.30 $m^3$/second and the surface water volume was $4.30\times10^9$ $m^3$, in 2012 the reliable discharge was 145.64 $m^3$/second and the surface water volume was $4.59\times10^9$ $m^3$, in 2013 the reliable discharge was 133.71 $m^3$/second and the surface water volume was $4.22\times10^9$ $m^3$, in 2014 the reliable discharge was 137.07 $m^3$/second and the surface water volume is $4.32\times10^9$ $m^3$, in 2015 the reliable discharge was 149.45 $m^3$/second and thewater volume was surface$4.71\times10^9$ $m^3$, in 2016 the reliable discharge was 145.82 $m^3$/second and the surface water volume $4.60\times10^9$ $m^3$, 2017 produced a reliable discharge of 146.05 $m^3$/second and a surface water volume of $4.\ 61\times10^9$ $m^3$, in 2018 the reliable discharge was 246.12 $m^3$/second and the surface water volume was $7.76\times10^9$ $m^3$, in 2019 the reliable discharge was 174.40 $m^3$/second and the surface water volume was $5.50\times10^9$ $m^3$, 2020 produced a reliable discharge of 155.58 $m^3$/second and a surface water volume of $4.91\times10^9$ $m^3$.

Based on the analysis of changes in surface water volume from 2011 to 2020, it can be predicted that the volume of river water in Kranji village for the next 20 years. The amount of surface water has increased to 19% in the 10th year, reached 28.5% in the 15th year and reached 39% in the 20th year.

## CONCLUSION

After conducting research on the effect of climate change on the availability of river water in Kranji Village, Kedungwuni Timur District, Pekalongan Regency, the following conclusions can be drawn:

1. The current condition of water availability in Kranji Village, Kedungwuni Timur District,

Pekalongan Regency is indicated to be able to meet existing needs. Nevertheless, it is seen that there is a decrease in discharge which could potentially lead to insufficient raw water needs in the future.

2. With climate change on the water crisis, it can lead to potential floods and droughts in Kranji Village, Kedungwuni Timur District, Pekalongan Regency. With a topography of mountainous and hilly areas, the area in Kranji Village, Kedungwuni Timur District, Pekalongan Regency does not have problems with potential seawater intrusion and sea level rise caused by climate change, however in some areas there are indications of potential landslides that can be caused by a long rainy season.

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