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The Impact of Climate Factors on Drinking Water Shortage in Indonesia

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Abstract – Water is a very vital natural resource and is needed to determine the sustainability of the life of all living things on this earth. The emergence of the effects of global warming due to increasingly erratic climate change results in an increase in regional temperature which results in the scarcity of clean water. The purpose of this study was to determine the effect of climate on the potential shortage of drinking water in Indonesia. The data used in this study is sourced from the 2018 National Socio-Economic Survey (SUSENAS) data, with a total of 293,651 observation households covering all provinces in Indonesia. The data analysis method used is Ordinary Least Square (OLS). The results of this study indicate that the intensity of rainfall has a negative effect on the potential for drinking water shortages in the territory of Indonesia. Meanwhile, the increase in air temperature and the increase in the duration of sunlight have a positive impact on the potential for drinking water shortages. The tendency for potential shortages of drinking water is higher in urban areas due to higher air temperatures, and the lack of water absorption in urban areas. It is necessary to be careful in the dry season where currently extreme weather occurs so that during the dry season at one time the air temperature is above the average so that it triggers a drought and results in a shortage of drinking water.

Keywords – Climate change, Drinking water shortage ,Indonesia, Ordinary Least Square (OLS).

I. INTRODUCTION

Water is a very vital natural resource and is needed to determine the sustainability of the life of all living things on this earth (Mawardi 2014). Water is the most abundant chemical compound in nature. The amount of water found on earth is relatively constant, even though the water experiences currents, circulates due to the influence of the weather and also changes shape. The circulation and changes in shape include surface water that turns into steam (evaporation), water that follows circulation in the plant body (transpiration) and water that follows circulation in the human and animal bodies (respiration). The water that evaporates will collect into clouds and then fall as rain (Arifin and Ramadhan 2021). Some rainwater joins directly on the surface, while some seeps into rock crevices in the ground, so that it becomes ground water (Susana 2003).

Based on (Permenkes RI No. 492/Menkes/Per/IV/2010) what is meant by drinking water is water that has been processed or without processing that meets health requirements and can be drunk directly. The requirements that must be met by drinking water include: bacteriological, chemical, physical and radioactive requirements. Given that basically there is no water that is 100% pure, in the sense that it meets the proper requirements for health, it must be endeavored in such a way that the required conditions must be fulfilled or at least close to the desired conditions (Kementerian Kesehatan 2010).

In all kinds of human activities, water is a basic need to carry out various activities, such as household needs, for example for drinking, cooking, bathing, washing, industrial purposes, trade purposes, agricultural and livestock needs, shipping purposes and so on (Prasetya, Waspodo, and Saptomo 2016). Therefore, water is very functional and plays a role in the life of living things on this earth. In line with the increase in the standard of living of humans, the need for water also increases. according to Rustan et all (2019) Water demand is the amount of water that is sufficient for basic human needs and other activities that require water.

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While water usage is the amount of water used from the existing system regardless of the circumstances. In big cities, it is not easy to get a source of clean water that is used as raw material for clean water that is free from pollution, because a lot of water is sucked in by industrial activities that require a certain amount of water to support its production. (Kusumawardani 2011).

The United Nations (UN) in 2019 noted that 2.2 billion people or a quarter of the world's population still lack safe drinking water. Meanwhile, 4.2 billion people do not have safe sanitation services and 3 billion do not have basic hand washing facilities. Meanwhile, according to the BAPPENAS report, the availability of water in most areas of Java and Bali is currently classified as scarce to critical. Meanwhile, the availability of water in South Sumatra, West Nusa Tenggara, and South Sulawesi is projected to be scarce or critical in 2045. The scarcity of clean water also applies to drinking water. According to the 2020-2024 RPJMN, only 6.87 percent of households have access to safe drinking water. Meanwhile, based on the 2020 National Socio-Economic Survey (SUSENAS) from BPS, it also shows that 90.21 percent of households have access to safe drinking water, although the distribution is uneven (Iswara 2021).

According to BAPPENAS, forest damage will trigger raw water scarcity, especially for islands with very low forest cover, such as Java, Bali and Nusa Tenggara. According to BAPPENAS, forest cover will also decrease, from as much as 50 percent of Indonesia's total land area (188 million hectares) in 2017, to only around 38 percent in 2045. The increasing population in Indonesia is also a new burden in providing water for the people of the country. According to the 2020 Population Census conducted by the Central Statistics Agency (BPS), Indonesia's population is 270.21 million people (BPS 2020). This number increased by 32.56 million people compared to the 2010 census results (Iswara 2021). Other causes of the water crisis are excessive groundwater extraction, high levels of pollution of water sources, conflicts of economic interest supported by inappropriate policies, and destruction of the environment and water sources. (Adlina 2011).

The potential for the availability of clean water from year to year tends to decrease due to environmental pollution and damage to water catchment areas (Kodoatie and Sjarief 2010). The condition is exacerbated by climate change which is starting to feel its impact, causing Indonesia to experience floods in the rainy season and drought in the dry season (Faradiba 2021). During the rainy season, if the intensity of rainfall is above normal, of course there will be flooding. During the flood, the PAM water supply was stopped because most of the water distribution pumps were submerged, the electricity went out and if people used dug wells, the dug well water was mixed with flood water. So practically there is only flood water which in quality cannot be used for drinking water. For drinking and cooking purposes, rely on bottled water/gallons which, when purchased and the price is very unreasonable, due to difficult transportation conditions. (Dwiratna and Kendarto 2018). It is different during the dry season where the air temperature is higher and if the air temperature is above the average, then the chance of drought can occur and result in scarcity of water sources.

The water crisis has often hit several areas, so that the population's water needs for household, agricultural and other basic needs are not fulfilled (Munawaroh et al. 2021). The direct impact of the lack of water needs, among others, namely the occurrence of failure to plant and harvest which causes disruption of food supplies, poor sanitation and hunger which has an impact on the emergence of diseases due to lack of food and malnutrition (Faradiba 2018; Jafar, Surusa, and Pratiwi 2019). Closely related to the water and food crisis is poor sanitation which is also a problem for around 2.0 billion people in the world. Many diseases due to the crisis of water and poor sanitation, such as diseases caused by hunger, malnutrition, cholera, typhus, and dysentery are still a threat to most of the world's population. According to a report by FAO (2000), about 2.0 million people, mostly children from several poor and developing countries, die each year from these diseases and due to water scarcity and hunger. The water crisis can also disrupt the regional and national economy (Mawardi 2017).

II. METHOD

The data used in this study was sourced from the 2018 National Socio-Economic Survey (SUSENAS) data, with a total of 293,651 household observations covering all provinces in Indonesia. In this study several climatic factors were analyzed such as rainfall, air temperature and solar radiation. The analysis method uses Ordinary Least Square (OLS) with climate factor as the independent variable and household water shortage as the dependent variable. The influence between variables can be seen from the coefficient value of the independent variable. In this study, it will also be disaggregated by urban and rural areas for the shortage of drinking water that occurs in the territory of Indonesia. To what extent are the impacts different for urban and rural areas experiencing a shortage of drinking water.

III. Results And Discussion

The effect of climate that occurs, especially the value of rainfall, air temperature and solar radiation on the potential for drinking water shortages, results can be seen in several tables that have been presented. This study also compares the potential shortage of drinking water in rural and urban areas caused by changes in these three climatic factors.

Table 1. Effect of Rainfall on Drinking Water Shortage

```
. reg r1513 hujan,r

Linear regression                               Number of obs     =    293,651
                                                F(1, 293649)      =     195.28
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0006
                                                Root MSE          =     .19869

------------------------------------------------------------------------------
             |               Robust
      r1513 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      hujan |  -.0001034   7.40e-06   -13.97   0.000    -.0001179   -.0000889
      _cons |    .060435   .0014662    41.22   0.000     .0575613    .0633088
------------------------------------------------------------------------------
```

Based on the table of the influence of rainfall factors on drinking water shortages in table 1, it can be seen that increased rainfall has a negative impact on drinking water shortages. In this case, the increase in rainfall value has a negative impact of 0.01%. These results illustrate that an increase in rainfall will reduce the potential for drinking water shortages in an area in Indonesia.

Changes in extreme weather that occur certainly affect the pattern of rainfall. Based on rainfall trend data, rainy days with an intensity of 20 mm/day tend to increase by 0.1149 days per year or 1,149 days per decade. (BMKG 2021). The intensity of rainfall in November 2021 in the Indonesian region is generally in the medium and high category, while the intensity of rainy days in November 2021 for the western part of Indonesia is generally in the normal category and in the eastern part of Indonesia it is generally in the category above the normal (BMKG 2021). The high intensity of rainfall and rainy days that occur and when compared with table 1, the tendency for potential water shortages does not occur. It's just that when viewed from the quality of water to be used as drinking water consumption, of course, it must pay attention to the quality standards or standards of drinking water eligibility based on the Minister of Health of the Republic of Indonesia No. 492/Menkes/Per/IV/2010.

Table 2. Effect of Temperature on Drinking Water Shortage

```
. reg r1513 suhu,r

Linear regression                               Number of obs     =    293,651
                                                F(1, 293649)      =     129.70
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0003
                                                Root MSE          =     .19872

------------------------------------------------------------------------------
             |               Robust
      r1513 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       suhu |   .0036497   .0003205    11.39   0.000     .0030216    .0042778
      _cons |  -.0587037   .0087434    -6.71   0.000    -.0758405   -.0415668
------------------------------------------------------------------------------
```

The results that can be seen in table 2 are the effect of air temperature on the shortage of drinking water, resulting in a coefficient of 0.0036497. The coefficient is positive, which can also be interpreted as an increase in air temperature that can increase the potential for drinking water shortages in an area in Indonesia. The hotter the air temperature, the less water sources in an area. An increase in air temperature can trigger drought so that the water supply becomes reduced. An increase in air temperature can increase the potential for drinking water shortages by 0.36%.

Based on data from 87 BMKG observation stations, the normal November air temperature for the 1981-2010 period in Indonesia is 26.6 ^{o}C (within the normal range 21.0 ^{o}C - 28.7 ^{o}C) and the average air temperature in December 2021 is 27.0 ^{o}C. Based on these values, the average air temperature anomaly in December 2021 shows a positive anomaly with a value of 0.4 ^{o}C. The Indonesian air temperature anomaly in December 2021 is the 9th highest anomaly value throughout the observation data period since 1981. The average air temperature anomaly per station in December 2021 obtained from 87 BMKG observation stations in Indonesia generally shows positive anomaly values. (hotter than the climatological average) which is dominant in almost all parts of Indonesia (BMKG 2021).

Based on the results of the processing of temperature trends in Indonesia, in general, the temperature in Indonesia, both the minimum, average, and maximum temperatures, has a positive trend with a magnitude that varies around 0.03 °C each year. This means that the temperature will increase by 0.03 °C every year so that in 30 years the location will increase by 0.9 °C (BMKG 2021). The existence of an increase in temperature that occurs continuously is not impossible in the next few years the temperature will increase to an above average category. Thus the potential for drought can occur. Even now, the existence of extreme weather such as extreme hot weather at some times of the year during the dry season certainly causes several areas in Indonesia to experience drought. Of course, if this happens, then the shortage of water sources can't be avoided.

Table 3. Effect of Sunshine on Drinking Water Shortage

```
. reg r1513 sinar,r

Linear regression                               Number of obs     =    293,651
                                                F(1, 293649)      =     613.48
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0025
                                                Root MSE          =      .1985

------------------------------------------------------------------------------
             |               Robust
       r1513 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       sinar |   .0011451   .0000462    24.77   0.000     .0010545    .0012357
       _cons |  -.0271533   .0027076   -10.03   0.000    -.0324601   -.0218464
------------------------------------------------------------------------------
```

In line with the results in table 2, the effect of sunlight also has a positive impact on the potential for drinking water shortages. The results of table 3 corroborate the results obtained in table 2. Based on the coefficient value in table 3, it is obtained at 0.0011451. This means that changes in sunlight can trigger a potential shortage of drinking water by 0.11%. The increase in the intensity of solar radiation is certainly in line with the increase in the value of air temperature in an area. Increasing the intensity of sunlight has an impact on increasing air temperature, which if the increase is extreme enough, of course, it will have the potential to cause drought.

During the dry season, the air temperature increases at the peak of the dry season, the temperature increases above average. In this condition, of course, sunlight will be maximized. The duration of sun exposure is certainly in line with the increase in air temperature. This has a positive impact on the potential for drinking water shortages in some areas experiencing drought.

The results of the three climate factors are then carried out a more specific analysis by dividing the area into 2 different parts, namely rural and urban areas. The next analysis is to see what the influence of these three climate factors is in two different regions.

Table 4. Effect of Rainfall on Drinking Water Shortage in Urban and Rural Areas

```
. reg r1513 hujan if r105==1,r

Linear regression                               Number of obs     =    126,070
                                                F(1, 126068)      =       0.14
                                                Prob > F          =     0.7075
                                                R-squared         =     0.0000
                                                Root MSE          =     .16459

------------------------------------------------------------------------------
             |               Robust
       r1513 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       hujan |   3.64e-06   9.72e-06     0.38   0.708    -.0000154    .0000227
       _cons |   .0271911   .0018537    14.67   0.000     .0235579    .0308243
------------------------------------------------------------------------------
```

a. Rural Areas

```
. reg r1513 hujan if r105==2,r

Linear regression                               Number of obs     =    167,581
                                                F(1, 167579)      =     285.17
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0016
                                                Root MSE          =     .22029

------------------------------------------------------------------------------
             |               Robust
       r1513 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       hujan |  -.0001736   .0000103   -16.89   0.000    -.0001937   -.0001534
       _cons |   .0836633   .0020802    40.22   0.000     .0795861    .0877404
------------------------------------------------------------------------------
```

b. Urban Areas

Based on Table 4, the coefficient values are different in the two regions. In rural areas the coefficient is negative, while in urban areas the coefficient is negative. Based on the results of these two tables, it can be explained that rain has an insignificant impact on household drinking water shortages in rural areas, but a significant negative impact is seen in urban areas. Based on these results in rural areas, it is certainly not significant because the water sources in rural areas are far more abundant than urban areas. In addition, in urban areas, especially big cities, the supply of drinking water is taken from drinking water sources that originate in rural areas.

The rainfall variable becomes insignificant in rural areas and has a negative impact in urban areas. This is in line with the results in table 1 that an increase in rainfall has a negative impact on the potential for drinking water shortages in an area.

Table 5. The Effect of Air Temperature on Drinking Water Shortage in Urban and Rural Areas

```
. reg r1513 suhu if r105==1,r

Linear regression                               Number of obs     =    126,070
                                                F(1, 126068)      =       5.44
                                                Prob > F          =     0.0196
                                                R-squared         =     0.0000
                                                Root MSE          =     .16459

------------------------------------------------------------------------------
             |               Robust
      r1513 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        suhu |  -.0009099     .00039    -2.33   0.020    -.0016742   -.0001455
       _cons |   .0527142   .0106779     4.94   0.000     .0317857    .0736427
------------------------------------------------------------------------------
```

a. Rural Areas

```
. reg r1513 suhu if r105==2,r

Linear regression                               Number of obs     =    167,581
                                                F(1, 167579)      =     279.61
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0010
                                                Root MSE          =     .22035

------------------------------------------------------------------------------
             |               Robust
      r1513 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        suhu |   .0090748   .0005427     16.72   0.000     .0080111    .0101385
       _cons |  -.1975999   .0147983    -13.35   0.000    -.2266042   -.1685956
------------------------------------------------------------------------------
```

b. Urban Areas

Based on table 5 when differentiated by region, the results obtained are different. In the table the coefficient value in rural areas is negative while in urban areas it is positive. Based on these results, it can be explained that temperature has a significant positive impact on household drinking water shortages in urban areas. The opposite effect is seen in rural areas. The existence of different results in the two regions is influenced by sources of drinking water producing more in rural areas. In addition, rural areas have other alternative sources of drinking water so that the impact is opposite. In urban areas, especially in big cities, drinking water sources are very limited.

The temperature level in urban areas is certainly higher than in rural areas. This is because the lack of Green Open Space (RTH) and increasing development activities in urban areas have resulted in less and less reforestation which results in the absorption of nutrients, one of which is water (Azzahra and Faradiba 2021). In contrast to urban areas, in rural areas there is still a lot of green open space and there is still a lack of development activity that occurs in this area.

Table 6. The Effect of Sunshine on Drinking Water Shortage in Urban and Rural Areas

```
. reg r1513 sinar if r105==1,r

Linear regression                               Number of obs     =    126,070
                                                F(1, 126068)      =      77.97
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0006
                                                Root MSE          =     .16454

------------------------------------------------------------------------------
             |               Robust
      r1513 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      sinar |    .000487   .0000551     8.83   0.000     .0003789     .000595
      _cons |  -.0012362   .0032622    -0.38   0.705      -.00763    .0051576
------------------------------------------------------------------------------
```

a. Rural Areas

```
. reg r1513 sinar if r105==2,r

Linear regression                               Number of obs     =    167,581
                                                F(1, 167579)      =     567.39
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0043
                                                Root MSE          =     .21999

------------------------------------------------------------------------------
             |               Robust
      r1513 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      sinar |   .0016293   .0000684    23.82   0.000     .0014953    .0017634
      _cons |  -.0459431   .0039902   -11.51   0.000    -.0537638   -.0381224
------------------------------------------------------------------------------
```

b. Urban Areas

The results obtained in table 6 for the duration of sunlight on drinking water shortages in rural and urban areas are positive for these two regions. These results can be interpreted that the duration of sunlight has a significant positive impact on the shortage of household drinking water, in rural areas as well as in urban areas. These results are in line with tables 2 and 3. The increase in air temperature, and the length of the duration of sunlight certainly have a positive impact on the potential for drinking water shortages in an area.

IV. Conclusion

The conclusion of this study is that the intensity of rainfall has a negative effect on the potential for drinking water shortages in Indonesia. Meanwhile, the increase in air temperature and the increase in the duration of sunlight have a positive impact on the potential for drinking water shortages. The tendency for potential shortages of drinking water is higher in urban areas due to higher air temperatures, and the lack of water absorption in urban areas. It is necessary to be wary of during the dry season where currently extreme weather occurs so that during the dry season at one time the air temperature is above the average so that it triggers a drought and results in the scarcity of drinking water.

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