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TREND ANALYSIS OF THE INCREASE OF AIR TEMPERATURE AND THE RAINFALL ON CLIMATE CHANGE IN MAROS DISTRICT

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ABSTRACT

Research has been carried out that aims to analyze and gain knowledge about the climate change that is happening in Maros Regency using descriptive, spatial, and explanatory statistical methods. The data used is daily climatic data for Maros Regency, which is processed using Ecxel, RCLIMDEX, and ArcGIS 10.4 software, which produces data in the form of graphics and spatial images. In addition, global factors are used as supporting data to determine its relationship with the climate of Maros Regency and to see whether climate change is occurring or only being influenced by global factors such as monsoons and El Nino/La Nina. The pattern of rainfall in Maros Regency is monsoonal; there has been no change in climate patterns for 30 years, and there has been a decreasing rate of rainfall, but there has been an increase in the amount of rainfall at the peak of the rainy season and a decrease in rainfall at the peak of the dry season every tenth of the year, and the extreme index has increased. The air temperature in Maros district is also experiencing an increasing trend, although it is more significant at the minimum temperature.

Keyword: climate change; rainfall; temperature; Maros Regency

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INTRODUCTION

Climate change is a global phenomenon that is currently taking place. In general, climate change is referred to as a global warming phenomenon, namely the process of increasing the average temperature of the atmosphere, sea, and land layers on Earth [1]. Global warming can also be the cause of extreme weather changes [2-4].

Seasons in Indonesia, besides being influenced by the monsoon [5], are also influenced by other factors that interact with the monsoon. One of these important factors is El Nino and La Nina [6] In Indonesia, climate change causes prolonged rainy and dry seasons, which ultimately results in an increase in the frequency of floods, long droughts, landslides, and forest fires. Moreover, when the El Nino and La Nina phenomena occur, the intensity of rainfall in Indonesia is greatly affected [7-8]. When La Nina occurs, rainfall increases, conversely when El Nino occurs, rainfall decreases [9-10] One of the areas experiencing an increase in the frequency of flood events is the Maros Regency in South Sulawesi Province. The regional profile of Maros Regency is quite varied and borders directly with Makassar City as the capital of South Sulawesi Province, as well as being integrated in the development of the Mamminasata Metropolitan Area, thus providing enormous opportunities for development in Maros Regency.

Another variable that exists in Maros Regency is the potential for excavated mining, which has been invested in through mining activities. This mining activity changes many sectors, namely changing the use of green land to mining land, increasing residential areas, and increasing the population due to the need for labor[11]. The various variations mentioned previously really support the development of cities, with the increasing population increasing the need for land. Changing open land to closed land also increases air temperature in urban areas [12].

In the end, all these changes allow climate change to occur in this region. One proof that climate change has occurred in Maros Regency is that there has been damage to cave wall paintings caused by contact with a different atmosphere. This occurs significantly in the rainy and dry seasons. Damage to the Leang-Leang cave wall paintings that occurred included the peeling of the layers of the cave walls on the paintings, the growth of moss or algae covering the paintings, and the paintings being erased by the flow of rainwater that passed through the paintings [13-14]. The impact of climate change occurring around the National Park area is an increase in the potential for flooding. Floods mostly occur due to high rainfall during the rainy season, which is supported by the characteristics of the land in the form of karst areas that drain water very quickly [15].

Previous research generally analyzed climate change conditions in large cities, such as Makassar City [16] and Malang City [12]. Therefore, it is also necessary to carry out research in areas that are still developing and are located close to large cities so that results can be obtained that show that the influence of climate change is not only in large cities but also in the surrounding areas that are also experiencing climate change. In this case, the author chose Maros Regency because, apart from its position, which is directly adjacent to Makassar City, land use in Maros Regency is also quite varied and supports climate change.

METHODS

Data

The data used were daily rainfall data and daily maximum air temperature and daily minimum air temperature events within the period of 1991 – 2020 collected from the Indonesia Agency for Meteorology, Climatology and Geophysics (BMKG) Region IV in Makassar. The rainfall data from 6 rain stations were collected, the daily minimum air temperature data from 2 weather observation station, wind direction and speed data from 1 weather observation station (Figure 1). and to determine the influence of El Nino and La Nina, ONI data (Oceanic Nino Index) is used, which is sourced from the website https://ggweather.com/enso/oni.htm, the data of which is the result of remote sensing from the NOAA satellite.

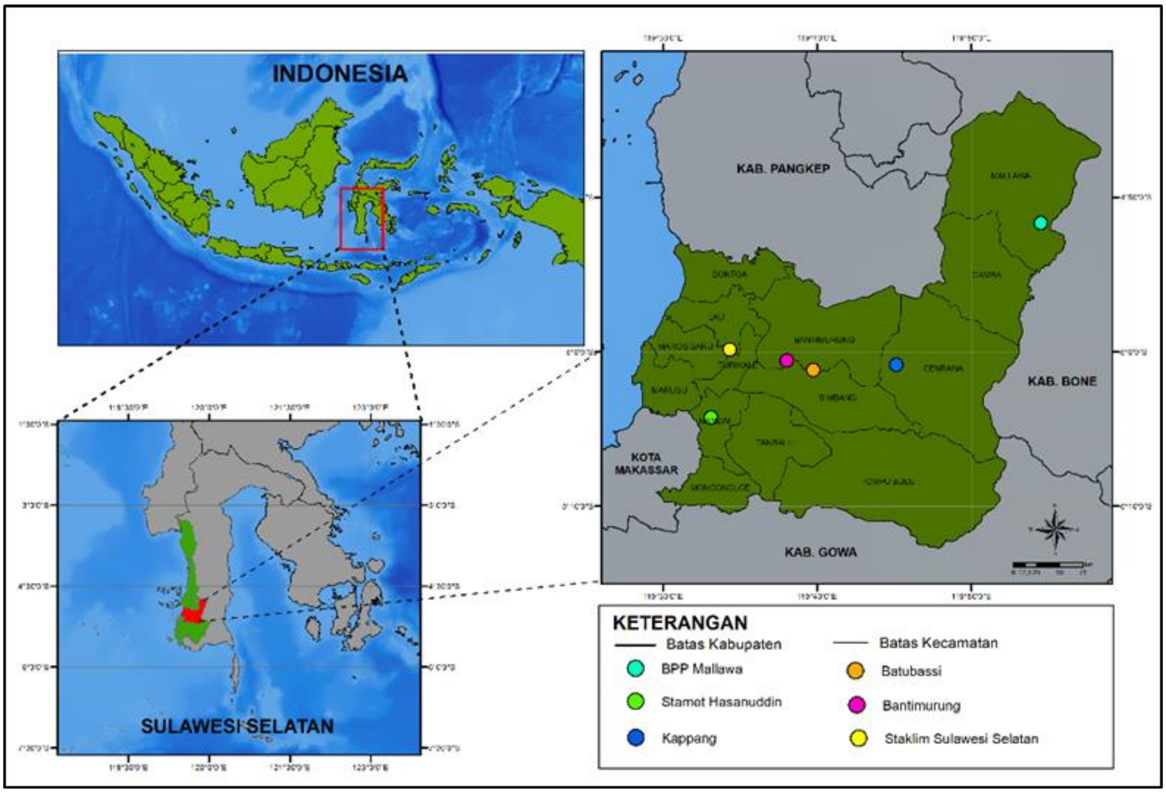


Figure 1. Research locations (the lines show district boundaries and the dots show rain stations).

Identification of Extreme Rainfall Events

The initial stage of the research was to collect daily weather data at the Maros climatology observation station as the climatological data coordinator for the entire South Sulawesi region in the observation period 1991–2020. In the form of postal rain data and climate data from the Maros climatology station and the Hasanuddin Meteorology Station in Maros Regency. Then data processing was carried out using Microsoft Excel software, both in preparing the data according to the format required for further processing and in further processing, which still used Microsoft Excel software to obtain statistical results. Then the data is compiled according to the format in Rclimdex to obtain the maximum and minimum temperature index trend above the 90th percentile value as the threshold for extreme values [17]. This calculation was performed using R-Climdex (available for download at www.r-project.org). Using explanatory analysis to find out how and why climate change occurs in Maros Regency and what causes this.

Spatial Analysis to Analyze Temporally

Identifying climate change in a region using spatial maps of ten-year (decadal) data distribution using the ArcGIS 10.4 application, which is software that functions as a geographic information system.

Analysis of the Influence of El Nino and La Nina

The influence of El Nino and La Nina on the climate in Maros Regency was analyzed using correlation coefficient (r-value). The classification [18] is presented in Table 1.

Table 1. Classification of correlation

r value	Description
0.00 – 1.199	Very Low
0.20 – 0.399	Low
0.40 – 0.599	Currently
0.60 – 0.799	Strong
0.80 – 1.000	Very Strong

RESULTS AND DISCUSSION

Air Temperature Profile and Rainfall Patterns in Maros Regency

In the dry months or during the dry season, the minimum temperature moves first compared to the maximum temperature; that is, if in the first month the minimum temperature is lower than the previous month, then the maximum temperature will also increase in the following month compared to the previous month. On the other hand, if the minimum temperature is higher in the first month compared to the previous month, then the minimum temperature will also be lower in the following month compared to the previous month. The relationship is inversely proportional but concomitant, which is why the lowest minimum temperature peak occurs in August and the highest maximum temperature peak occurs in September. However, during the rainy season, the maximum and minimum temperature patterns are directly proportional to each other at the same time, and the amplitude values are not as high as during the dry season.

Maros Regency's rainfall pattern is in accordance with the monsoon rainfall pattern, which is unimodial (one peak of the rainy season), where in July, August, and September the dry season occurs, while December, January, and February are the wet months. Meanwhile, the remaining six months are a transition period (three months from the dry season to the rainy season and three months from the rainy season to the dry season). Rainfall in Maros Regency has decreased by 8.29mm/year, or 0.26% of the average annual rainfall, which is 3329 mm, which, when compared with other regions, is an anomaly because in general other regions experience an increase in rainfall.

The distribution of wind direction throughout the year in Maros Regency is dominantly blowing from the east, with a percentage of 74% per year. From these results, it can be concluded that the climate of Maros Regency is less influenced by monsoon factors, even though the shape of the rain pattern shows a monsoon pattern. This is because the distribution of wind direction does not meet the requirements for areas influenced by monsoon movements.

To determine the influence of El Nino/La Nina in Maros Regency, the first thing to do is observe the years when El Nino/La Nina occurred globally. Then, to find out whether in those years the Maros Regency area experienced significant influence or not, the ONI index (Oceanic Nino Index) was used to find out whether an area's climate was influenced by global factors El Nino and La Nina or not. To find out what the effect is, a statistical process was carried out by correlating the ONI index with monthly rainfall data for 30 years in Maros Regency.

The trend of the maximum and minimum temperature index is above the 90th percentile value, as the threshold for extreme values. The TX90P trend for Staklim South Sulawesi has decreased (Figure 2a), while the TN90P trend has increased (Figure 2c). Stamet Hasanuddin's TX90P and TN90P trends both show an increase (Figure 2b and Figure 2d). This shows that generally the extreme temperature index has increased, so it can be concluded that extreme temperature events in Maros Regency are occurring more frequently than they did 30 years ago in that area. From the results of processing ten-year air temperature data, it shows that the rate of increase in minimum temperature is higher than the maximum temperature, because the minimum temperature occurs in the early morning, this shows that from year to year the air temperature at night gets warmer and continues to get warmer in the future. Meanwhile, although the air temperature during the day has increased, the rate is still less fast than the air temperature that occurs at night. If it is related to global warming, the increasingly warm air temperature at night is the result of the increasing accumulation of greenhouse gases in the earth's atmosphere which blocks the emission of long wave radiation released by the earth's surface at night. Because it is blocked, the long wave radiation that should radiate outward remains and further warms the atmosphere at the earth's surface.

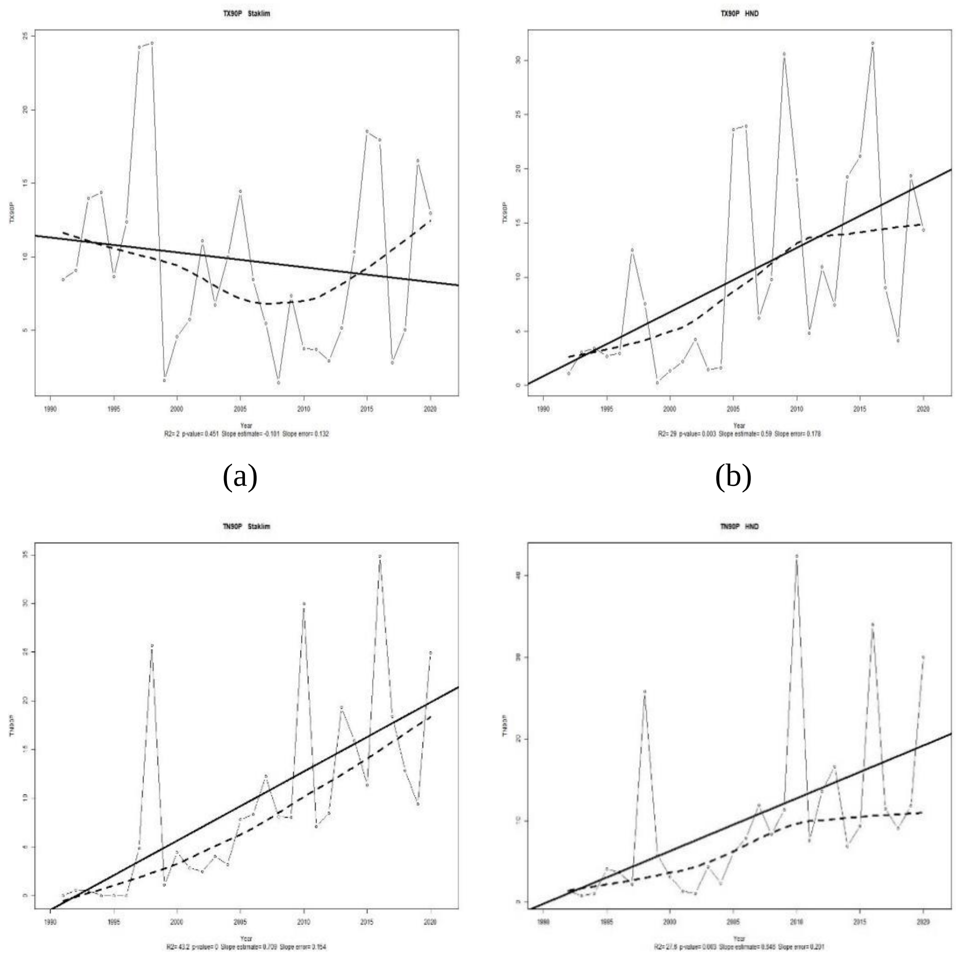
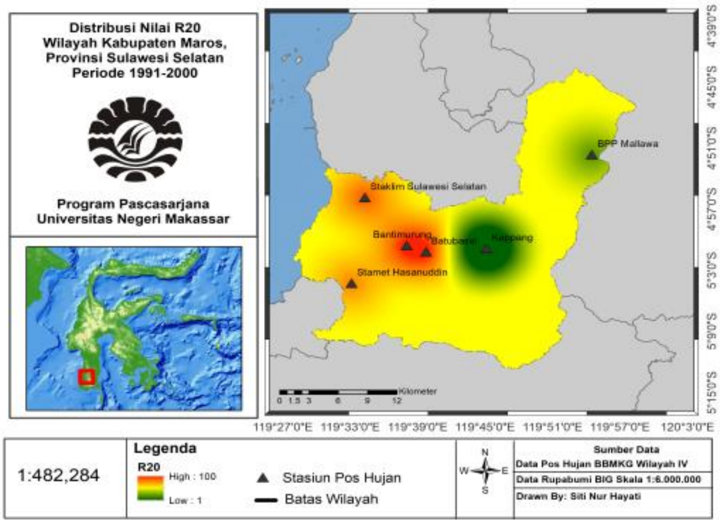


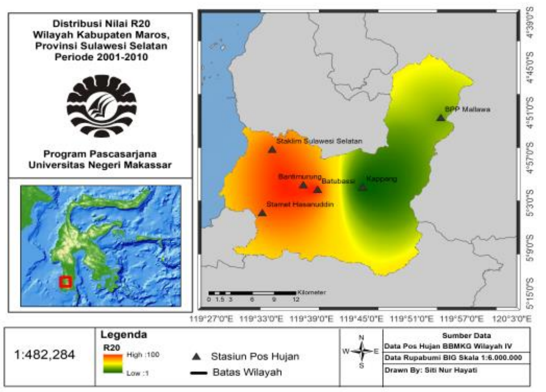
Figure 2. Temperature trends: (a) TX90P Staklim South Sulawesi and (b) TX90P Stamet Hasanuddin (c) TN90P Staklim South Sulawesi and (d) TN90P Stamet Hasanuddin in Maros Regency 1991 – 2020

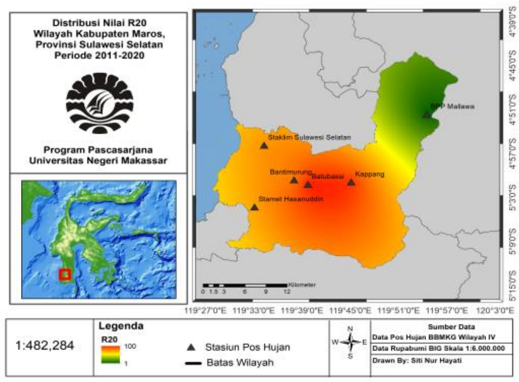
The ten-year rainfall profile of Maros Regency shows that only in the first ten years did rainfall increase, while in the following two decades rainfall in Maros Regency decreased. Where the average tenth annual rainfall decreased by 143mm/decadal or 4.5% of the average value. If it is projected that in the future, rainfall in Maros Regency will decrease if this continues.

The spatial distribution of the ten-year frequency of rainfall events ≥ 20mm (moderate – heavy rain) in Maros Regency, shows that generally the area that experiences more frequent rainfall events ≥ 20mm experiences an increase in area every ten years. In the first decade, the frequency of rainfall ≥ 20mm which was more frequent and which was less frequent was almost, which was more frequent in the coastal part of Maros Regency and less frequent in the mountainous part of Maros Regency equal (Figure 3a). Meanwhile, in the second and third decades, areas with more frequent rainfall events ≥20mm increasingly expanded to the mountainous parts of Maros Regency (Figure 3b). The third decade shows the extent of areas with lower frequencies remaining only in mountainous areas. This shows that there is an expansion of the area of extreme rain events in the Maros Regency area (Figure 3c).



(a)



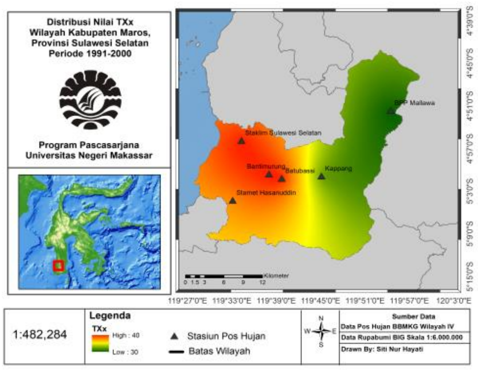


(b) (c)

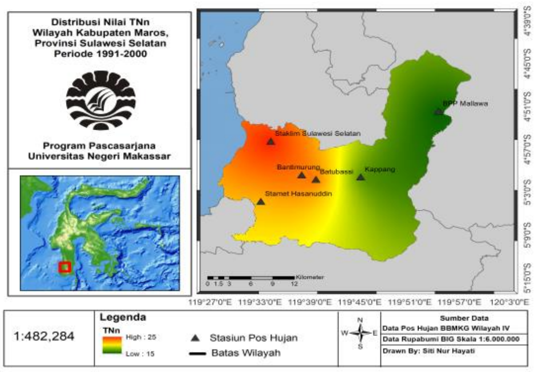
Figure 3. Spatial distribution of frequency of rainfall events ≥ 20mm in Maros Regency (a) 1991 – 2000 (b) 2001 – 2010 (c) 2011 – 2020

The results of the air temperature profile analysis in Maros Regency were produced from data processing using Excel software which showed 3 different results from processing data on maximum, minimum and decadal temperatures, both monthly data and annual data for 30 years. This is due to differences in the nature, occurrence and time span of the two types of temperatures studied. These two temperature data are obtained from the daily observation process on a thermometer installed in a meteorological cage. The difference is the nature of the sensor and the time of reading the data. The maximum temperature is read at night when the sun's heat no longer affects the earth's surface, while the minimum temperature is read in the morning. the day after the lowest temperature is unlikely to occur again.

The results of the monthly temperature profile analysis show that the average maximum temperature profile has the highest peak in September and the lowest valley occurs in January in Maros Regency in accordance with the results of rainfall data processing which shows that the rainfall pattern in Maros Regency is monsoon in form with peak rainfall occurring in January and the peak of dry season occurs in August. The highest amount of rainfall occurred in 1996 at 5126 mm/year, while the least rainfall occurred in 2019 at 1930mm/year. Maros Regency experienced a decrease in rainfall of 8.29 mm/year or 0.26%, which when compared with other regions is an anomaly, because in general other regions experience an increase in rainfall. Meanwhile, for the global influence analysis, none of them shows a strong correlation either from monsoon factors or El Nino and La Nina.



(a)



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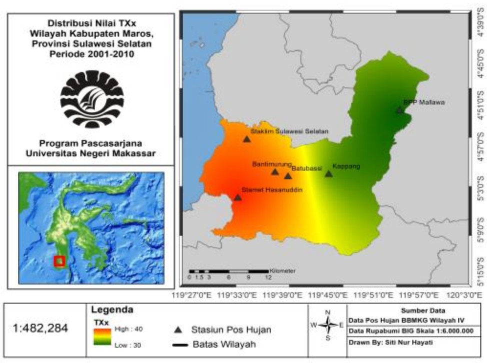

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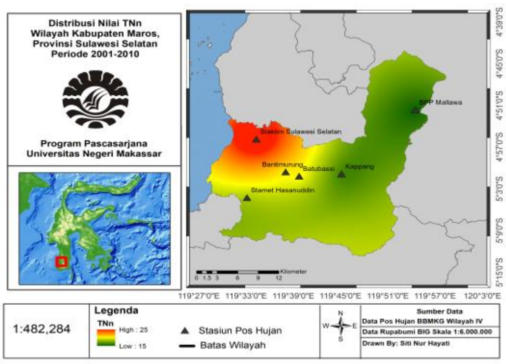

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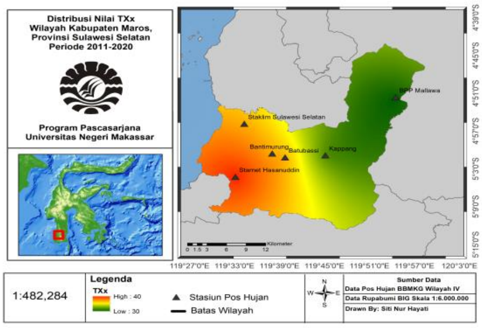

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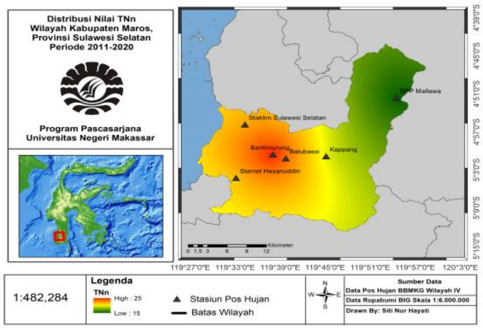

(f)

Figure 4. Spatial distribution of maximum temperature in Maros Regency (a) 1991 – 2000 (b) 2001 – 2010 (c) 2011 – 2020 and minimum temperature (d) 1991 – 2000 (e) 2001 – 2010 (f) 2011 – 2020

The influence of air temperature on climate change can be seen in the 90th percentile trend analysis, as the threshold for extreme values. The data is processed in the RClimdex application, the results generally increase. This shows that extreme temperatures in Maros Regency increased, the maximum air temperature and average decadal 1 air temperature increased by 0.03°C and 0.1° or 0.09% and 0.73%, the maximum air temperature average decadal 2 decreased by - 0.027°C and the minimum increased by 0.273°C or 0.01% and 1.49%. Meanwhile, for the 3rd decade, both experienced an increase of 0.1°C and 0.2°C or 0.27% and 0.17%. For the decadal spatial distribution of maximum and minimum temperatures, the area has expanded from coastal areas to mountainous areas (Figure 4). Analysis of the decadal rainfall graph shows that there has been no shift in the seasonal pattern for 30 years, both the rainy season and the dry season, the rate of decrease in rainfall is 143mm/decadal or 4.5%. However, the frequency of rainfall ≥20mm/day, which indicates moderate to very heavy rainfall, spatially also experiences regional expansion from the coast to the mountains.

CONCLUSION

The monthly air temperature profile shows that the highest peak average maximum temperature occurs in September and the lowest valley occurs in January in Maros Regency in accordance with the results of rainfall data processing which shows that the rainfall pattern in Maros Regency is monsoon-shaped with peak rainfall occurring in January and the peak of dry season occurs in August. The influence of the Monsoon and El Nino/La Nina on climate change in Maros Regency shows that these two global factors do not provide a strong correlation to the occurrence of climate change in Maros Regency. The influence of climate change on air temperature in Maros district can be seen in the minimum air temperature trend value which is higher than the maximum air temperature trend, where the increase in air temperature occurs at night due to the presence of greenhouse gases which block long wave radiation from the earth's surface. The influence of climate change on rainfall in Maros Regency shows that the frequency of rainfall is more than or equal.

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