Near future prediction of rainfall distribution pattern by adaptive neuro fuzzy interference system in Central Java, Indonesia

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Abstract: Rainfall distribution pattern is very important for sustainable production in the agricultural sector in Tropical region. The near future rainfall amount under changing climate was predicted from 2009 to 2028 by Adaptive Neuro Fuzzy Inference System (ANFIS), which was trained with the rainfall observation data from 1979 to 2013, spatiotemporally in the Central Java Province, Indonesia. Our analysis showed that the predicted rainfall data using ANFIS could represent actual rainfall conditions. Rainfall predicted from 2009 – 2028 in Central Java will experience a decrease in high rainfall in an area of 1,615,125.2 hectare, which can cause drought. The area that predicted to experience drought in the future are Kebumen, Jepara, Pati, Rembang, Kudus, Grobogan, Blora, Sragen, and parts of the regions of Purworejo, Cilacap, Banyumas, Brebes, Wonogiri, Karanganyar, and Demak.

Keywords: climate change, rainfall pattern, ANFIS, Central Java

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1 Introduction

Climate change occurs globally, both in tropical, sub-tropical, temperate and polar regions. According to Mawardi (2016), climate change, a direct result of global warming, already, is and will continue occur on earth. The direct result of climate change is a change in the hydrological cycle which results in changes in water availability (quantity and quality) of water that can be utilized by plants, animals and also humans. This change in water availability will directly affect the environmental system of plants, including agricultural crops, both in the regional and global regions. The water crisis is likely to threaten several countries, especially islands such as Indonesia as predicted by the FAO (Sekhar, 2018).

Based on research conducted by Nugroho (2015), it is known that climate change is causing changes in rainfall patterns in Central Java Province. Based on identification from Regional Disaster Management Agency and related agencies in 2019, there are 1,319 villages in 287 sub-districts in 31 districts / cities in Central Java prone to experiencing drought. BMKG (2019a) and Yuwono (2019) also stated that Central Java Province had the most drought areas in Indonesia, then East Nusa Tenggara and East Java Provinces. Based on data from the Central Java, Indonesian Red Cross (PMI) data, in October 2019, as many as 12,088,000 liters of water have been distributed to 473 villages in 26 districts/cities to overcome the drought that occurred. The distributed water is used for daily needs and irrigated the rainfed lowland rice fields. Meteorology, Climatology, and Geophysical Agency

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(BMKG) also stated that the drought in Central Java was the worst since 2015 (Kencana, 2019).

Head of the Horticultural and Plantation Food Crop Protection Center, Central Java Agriculture and Plantation Office, Herawati (2019) said that a total of around 70,000 hectares of agricultural land in Central Java had experienced drought. However, from that amount, only around 17,902 ha experienced crop failure. The most affected area is in Cilacap, which is around 4,000 ha, then Kebumen and followed by Grobogan (Saputra, 2019). This is certainly a serious problem that must be handled properly by the government, as one of the efforts to mitigate drought. By predicting rainfall and land mapping, the government can be used as a reference to determine good actions to reduce or anticipate the effects of drought.

Nugroho et al. (2020), in his research stated that the global climate index, such as Southern Oscillation Index (SOI), Sea Surface Temperature Nino 3.4, Sea Surface Temperature Nino West, and Indian Ocean Basin-wide Warming (IOBW) affected rainfall patterns in the Special Region of Yogyakarta. The global climate index has different effects on rainfall patterns, such as SOI and SST Nino 3.4 having a high negative correlation to rainfall distribution, which means that the increase in the value of those indexs are causing drought in several regions in Yogyakarta and Central Java Province, Indonesia.

Globally, climate change has an impact on temperature and rainfall fluctuations, which resulted in the drying out of several reservoirs and changing cropping patterns (Umar et al., 2019). Strauch et al. (2015) stated that climate change was not only causes drought, but can also cause an increase in rainfall due to extreme climatic conditions. Based on the research (Oktaviani et al., 2011), global climate change has a major impact on the agricultural sector, especially in Indonesia. In 2030, it is predicted that an increase in temperature of 0.8°C will result in a significant decrease in rice, corn and soybean production.

Future climate prediction research is very meaningful for developing strategies for protecting freshwater ecosystems, and also to maintain and increase food production. Rainfall distribution prediction data obtained in this study can be used by the government to develop strategies for increasing agricultural production in the future in an effort to tackle the impact of climate change in the agricultural sector.

2 Materials and methods

2.1 Study area

Central Java is one of the provinces on the island of Java, located between two large provinces, namely West Java and East Java. It is located between 5°40' and 8°30' South Latitude and between 108°30' and 111°30' East Longitude (including Karimunjawa Island). A map of Central Java Province can be seen at Figure 1.

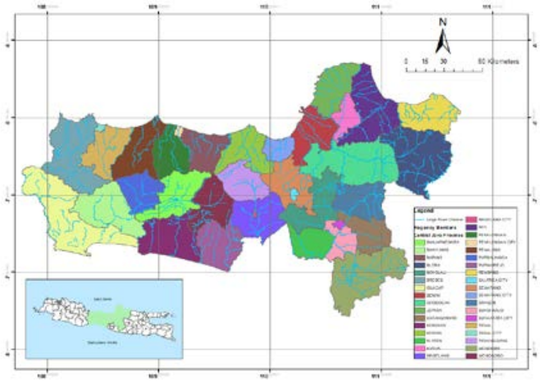

Figure 1 Research Target area in central Java Province in Indonesia

Central Java Province is divided into 29 districts and 6 cities. The total area of Central Java is 3.25 million ha, which is around 25.04% of the area of Java and 1.70% of the total area of Indonesia (BPS, 2017a).

According to Class I Climatology Station Semarang, the average air temperature in Central Java in 2015 ranged from 23°C to 28°C. Places that are located close to the beach have relatively high average temperatures. For the average humidity varies, from 69% to 83%. The highest rainfall was recorded at the Banjarnegara meteorological station with 3624 mm and the most rainy period was recorded at the Banjarnegara station during 179 days (BPS, 2016).

2.2 Rainfall data acquisition

The rainfall data was obtained from the National Center for Atmospheric Research (NCAR, 2019). Rainfall data was obtained from 87 data locations (Figure 2), having daily data for 35 years (1979-2013).

Based on research that has been done, climatology data from the National Center for Atmospheric Research is better than the nearest weather station (Fuka et al., 2014) since CFSR climate data has advantages over conventional data because it provides a complete set of climate data (Dile and Srinivasan, 2014).

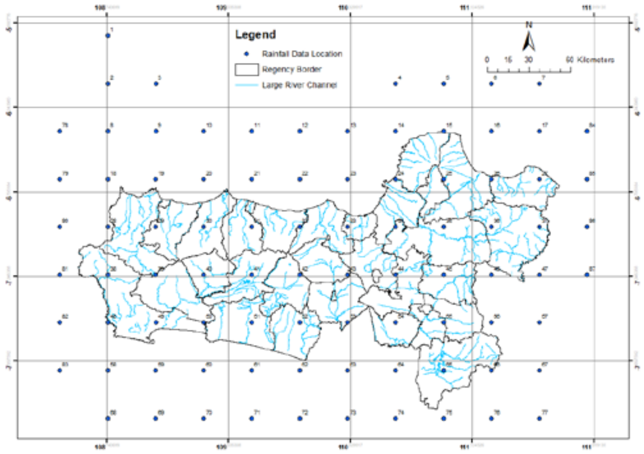

Figure 2 Rainfall data location

2.3 ANFIS model generation and rainfall data prediction

Adaptive Neuro Fuzzy Inference System (ANFIS) belongs to hybrid system and class of adaptive networks that incorporate both neural networks and fuzzy logic principles (Jang, 1993).

ANFIS model generation used the membership function type of gbellmf/ generalized bell-shaped membership function and using Sugeno fuzzy inference system. The gbellmf type was the best (with the smallest RMSE value) compared to using other function types. The ANFIS model was generated using five inputs and one output, and has 243 rules (hidden layer), the structure of the model can be seen in Figure 3.

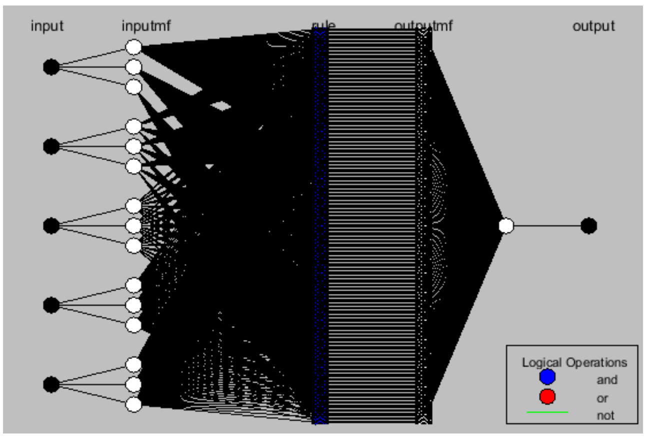

Figure 3 Rainfall prediction ANFIS model architecture using 243 hidden layer

The ANFIS model generation in this research used the 35-years rainfall yearly data and was divided into seven data groups, namely (1979 – 1983), (1984 – 1888), (1989 – 1993), (1994 – 1998), (1999 – 2003), (2004 – 2008), for model training and (2009 – 2013) for validation of the model. ANFIS models were made as many as 87 models, the same as the number of station data in Central Java Province, Indonesia.

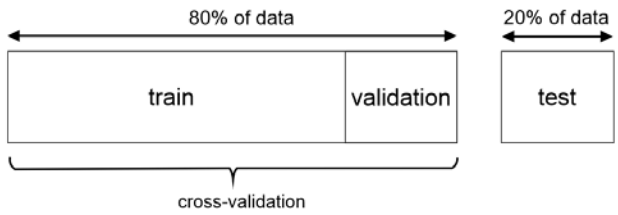

Figure 4 ANFIS modeling scheme

Data were grouped due to meet the requirements of ANFIS model in recognizing patterns of large amounts of historical data, and in order not to lose the value of historical rainfall data from 1979 – 2013. Models are evaluated using Root Mean Square Error (RMSE) equation as follows:

$$RMSE = \sqrt{\frac{\sum_{t=1}^{n}(x_{1,t} - x_{2,t})^2}{n}} \quad (1)$$

After getting the model with the smallest RMSE value, the model is tested to predict rainfall data and compared with the actual data. The parameter used as a reference that the model is good and can be used to predict the future rainfall data is the value of the coefficient of determination (R^2), which is the square of the correlation equation (R):

$$R = \frac{\sum_{t=1}^{n} x_{1,t}x_{2,t} - nx_1x_2)^2}{\sqrt{\sum_{t=1}^{n} x_{1,t}^2 - nx_1^2}\sqrt{\sum_{t=1}^{n} x_{2,t}^2 - nx_2^2}} \quad (2)$$

2.4 Rainfall data transformation

Predicted rainfall data that has been obtained for each data station, are changed into spatial data using Inverse Distance Weighting (IDW) interpolation in ArcGIS software. Inverse Distance Weighting (IDW) equation as follows:

$$Z_p = \frac{\sum_{i=1}^{n}\left(\frac{z_i}{d_i^p}\right)}{\sum_{i=1}^{n}\left(\frac{1}{d_i^p}\right)} \quad (3)$$

The Inverse Distance Weighting (IDW) method is used because it has a high accuracy value than the other methods (Pramono, 2008; Fajri, 2016). The final step is to observe changes in the annual rainfall pattern distribution, by classifying the amount of rainfall and its coverage area.

3 Results and discussions

3.1 Rainfall prediction

The RMSE value and the coefficient of determination of the ANFIS model for each data station can be seen in Figure 5.

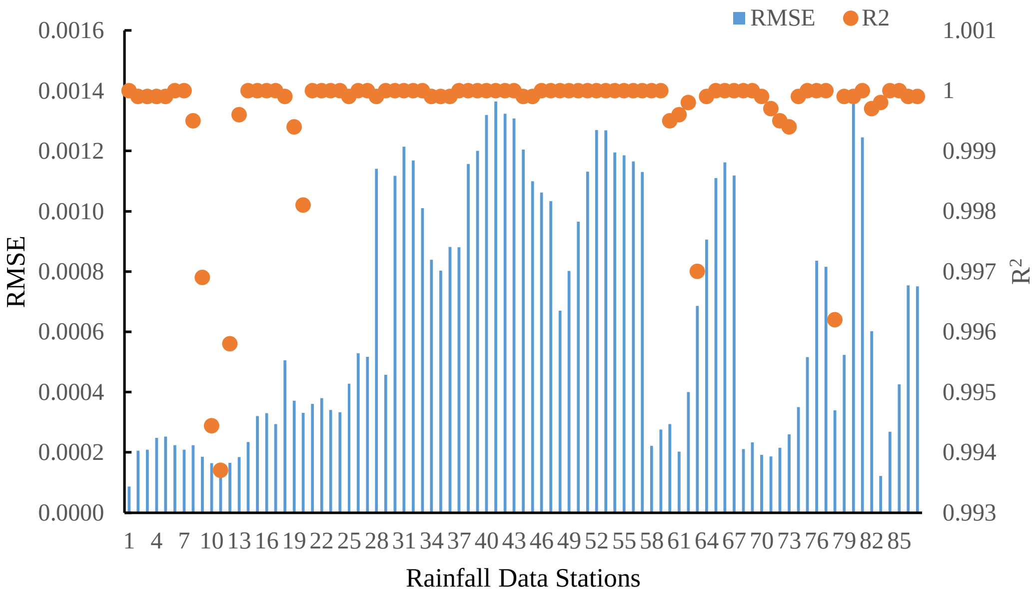

Figure 5 RMSE and coefficient of determination value of ANFIS model developed for rainfall prediction

Based on predictions using the developed model, annual rainfall data up to 2028 was obtained. Comparison of the average annual rainfall from 2009 - 2028 can be seen in Figure 6.

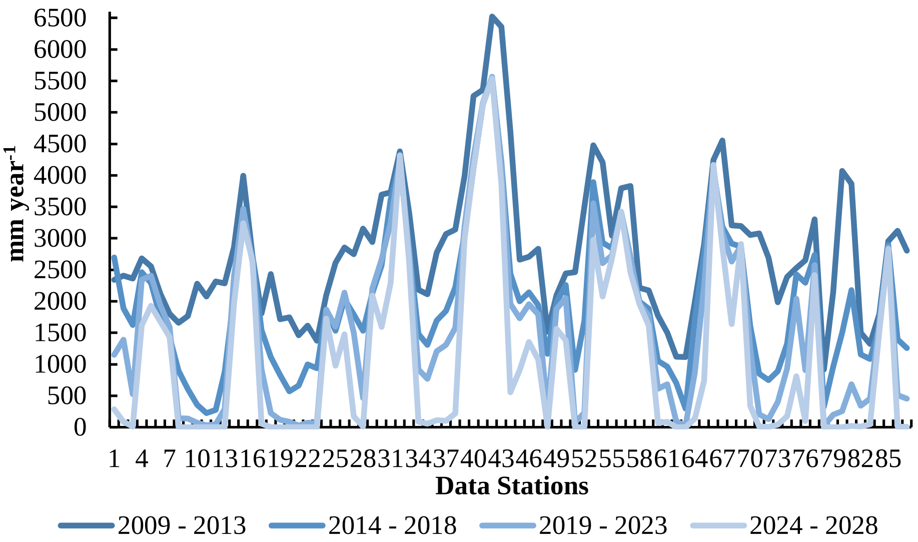

Figure 6 Average annual rainfall prediction in Central Java Province, Indonesia for different periods

The average rainfall in Central Java Province (Figure 6) for 5 years from 2009 - 2013, 2014 - 2018, 2019 - 2023, and 2024 - 2028 respectively decreased by 833.14 mm, 390.66 mm, and 428.78 mm. If compared from 2019 to the prediction in 2028, Central Java Province will experience a decrease in rainfall of 1652.5 mm.

Based on these data, most of the rainfall continue to experience a significant decrease every year, only few area still have high rainfall. These results concur with (Avia, 2019), in her research on Change in rainfall per decade over Java Island, Indonesia, changes in rainfall distribution patterns have occurred on the Indonesian island of Java. In general, in Central Java there is a decrease in rainfall, but each region has different characteristics. There is a decrease in rainfall with high intensity, and there is also a low, however, most regions experience a decrease in rainfall with high intensity. Parkhurst et al. (2019) also stated that, drought projection for Java island showed that the severity of the drought was increasing. In 2019, Central Java has already been on standby status, because it has experienced days without rain for more than 31 days and the prospect of low rainfall opportunities of less than 20 mm tendays^{-1} in the coming 20 days is more than 80% (BMKG, 2019b).

3.2 Rainfall pattern prediction and analysis

Average annual rainfall data that was obtained from 2009 - 2028 was changed into spatial data to be able to see the changes on the pattern. Rainfall patterns in Central Java Province can be seen in Figure 7 to Figure 10.

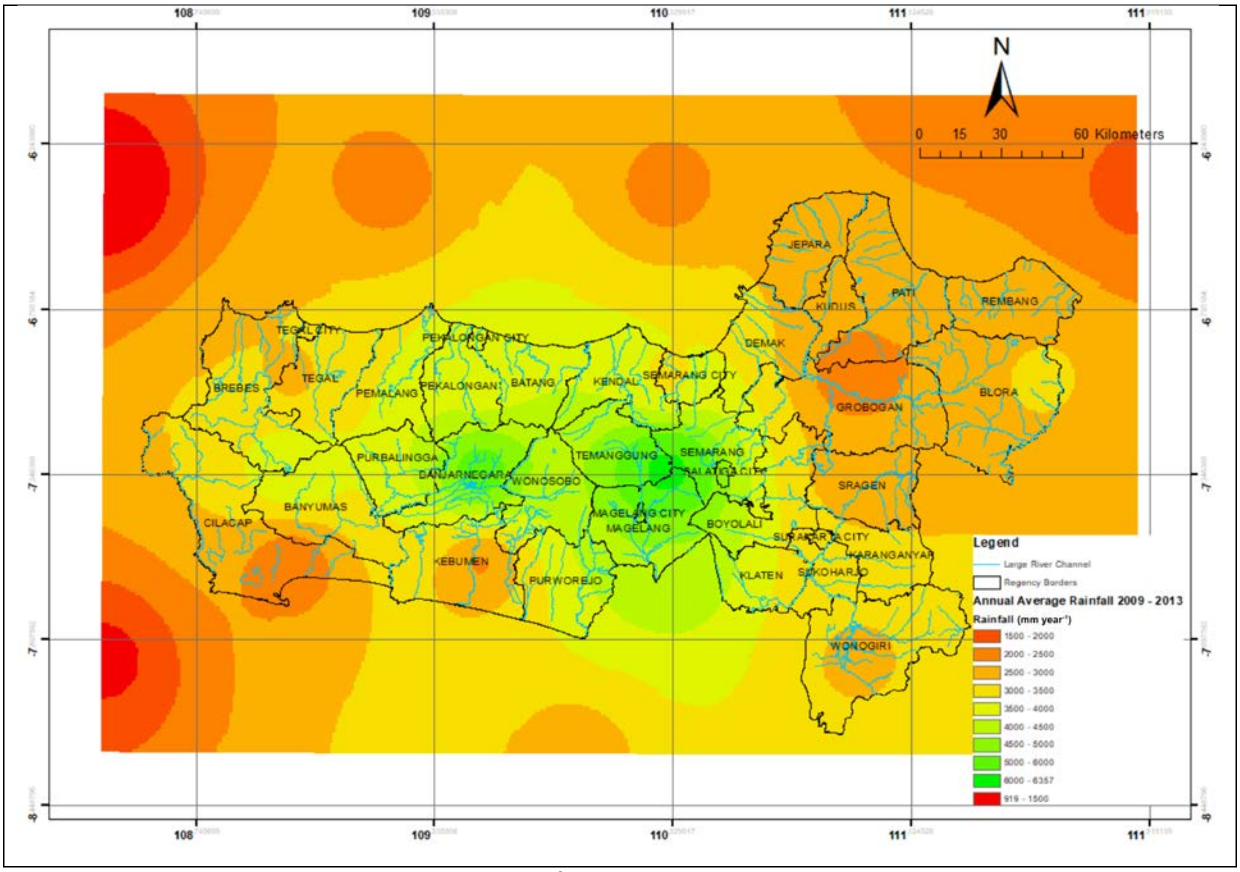

Figure 7 Annual average rainfall in Central Java, Indonesia 2009 – 2013

Based on the Figure 7, the highest rainfall in central Java in 2009-2013 was in the central area, and the rainfall decreased towards the east, south, west, and north. The pattern was still the same up to the ocean area, in the Java sea, rainfall is decreasing to the southwest, northwest, and northeast. These data are in accordance with rainfall data published by BPS (2017b), in 2013 rainfall at the Semarang City Station in Central Java was 2,628 mm year^{-1}, at Bandung Station in West Java Province at 2,327 mm year^{-1}, and at Juanda Station in East Java Province of 1,816 mm year^{-1}.

In 2009-2013, most areas in Central Java Province had medium rainfall with rainfall of around 2,000-4,000 mm year^{-1}, areas with a range of rainfall cover an area of 2,696,205.51 hectare (82.19% of the total surface). Other areas with high rainfall, with a range of 4,000-6,357 mm year^{-1}, cover an area of 583,894.48 hectare (17.81%). Details of the area with the amount of rainfall can be seen in Table 1.

In 2009-2013 rainfall was high enough and resulted in flood disasters in several areas. Thus, 17,925 ha of rice, corn and soybean farmlands were flooded in Kendal, Demak, Grobogan, Pati, Kudus, Jepara, Tegal, Pekalongan, Batang, Pemalang, and Pekalongan City Regencies, and 8,848 ha were severely damaged and failed to harvest in Demak, Grobogan, Pati, Kudus, Jepara, and Pekalongan Regencies (Narwanti, 2009). In 2013, floods also occurred in Purworejo Regency, floods and landslides hit 53 villages in 11 districts in Purworejo Regency, Central Java. The Bogowonto River and its tributaries overflowed, some river embankments have broken down, such as in the villages of Kemiri, Bayan, and Butuh (Nugroho, 2013). These events can prove that rainfall data from the National Center for Atmospheric Research represented actual rainfall in Central Java Province, Indonesia.

In addition to the flood disaster, drought was also occurred in Blora Regency and Rembang Regency covering an area of 1,085 hectares, which occured because of the dry season with a decrease in high rainfall (Nursyirwan, 2009). Based on Fifth Assessment Report of the Intergovernmental Panel on Climate Change 2013, reduced precipitation in Indonesia (especially July to October) is due to the pattern of Indian Ocean warming (Stocker et al., 2013).

Table 1 Average annual rainfall in Central Java Province, Indonesia, 2009 – 2013

Average Rainfall (mm $year^{-1}$)	Category	Regional Coverage	Area (hectare)	Total (hectare)
2,000 – 2,500	Medium	Tegal, Tegal City, Brebes, Cilacap, Kebumen, Wonogiri, Sukoharjo, Surakarta, Karanganyar, Sragen, Grobogan, Blora, Rembang, Pati, Jepara, Kudus, Demak, Semarang City, and some areas of the district of Banyumas and Pekalongan.	130,059.12	2,696,205.52
2,500 – 3,000			1,045,617.12	
3,000 – 3,500			887,905.11	
3,500 – 4,000			632,624.17	
4,000 – 4,500	High	Banjarnegara, Wonosobo, Temanggung, Semarang, Magelang, Purworejo, Klaten, Boyolali, Salatiga, Kendal, Batang, Pekalongan, Pekalongan City, Purbalingga, some areas of the district of Banyumas and Pekalongan.	322,228.19	583,894.48
4,500 – 5,000			154,788.62	
5,000 – 6,000			93,061.03	
6,000 – 6,357			13,816.64	
Total (hectare)			3,280,100	

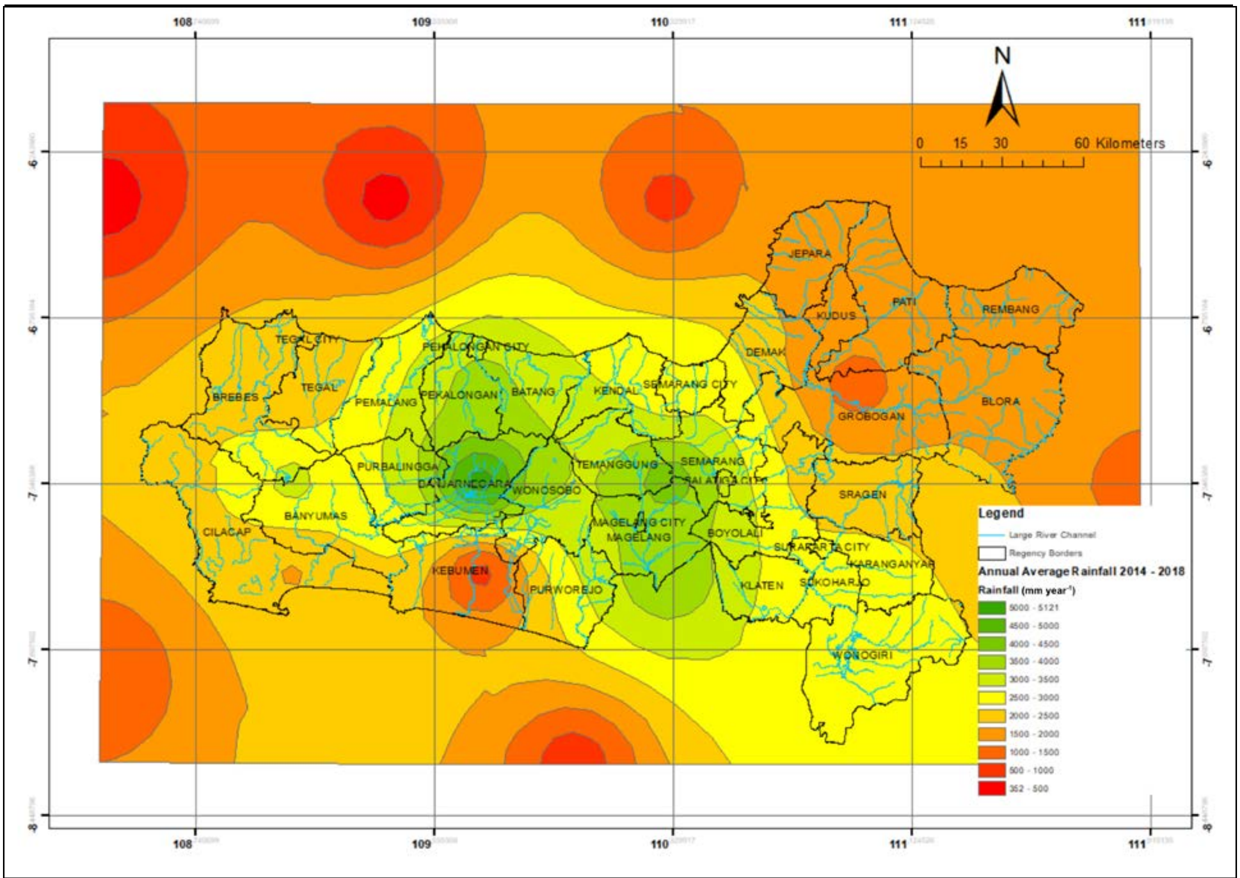

Figure 8 Annual average rainfall in Central Java, Indonesia 2014 – 2018

In 2014 – 2018, the rainfall pattern was still the same up to the ocean area, in the Java sea, rainfall is decreasing to the southwest, northwest, and northeast, but there is a decrease in rainfall compared to the previous 5 years (Figure 8). In Central Java Province, generally the rainfall pattern in 2014-2018 still had the same pattern as the previous 5 years, but there was a decrease in annual rainfall around 1,236 mm. In 2014-2018, there were several regions that experienced a decrease in rainfall. Areas that had low rainfall or around 500-2,000 mm year^{-1} covered an area of 804,255.81 hectare (24.52%). Areas with medium rainfall or around 2,000-4,000 mm year^{-1} covered an area of 2,386,608.61 hectare (72.76%), decreased by 9.43% from the last 5 years. Areas with high rainfall, or around 4,000-5,121 mm year^{-1} covered an area of 89235,57 hectare (2.72%), decreased by 15.09% from the last 5 years. Details of the area with the amount of rainfall can be seen in Table 2.

Parwito (2014) and Royanto (2014) stated that 24 Regencies in Central Java had experienced drought, and 12 of them had been affected by severe drought. The area consists of Rembang Regency, Pemalang Regency, Klaten Regency, Kendal Regency, Semarang Regency, Demak Regency, Kebumen Regency, Magelang Regency, Purworejo Regency, Blora Regency, Wonogiri Regency, and Grobogan Regency. The statement is also in accordance with the predicted rainfall data, where the southern, southwest, west, northwest, north and northeast regions of Central Java Province have low annual rainfall.

Based on the 2018 IPCC special report, global temperatures have increased by 1.5^{o}C and resulted in increases in both land and ocean temperatures, as well as more frequent heatwaves in most land regions (high confidence). There was also (high confidence) global warming that resulted in an increase in the frequency and duration of marine heatwaves. Further, there is substantial evidence that human-induced global warming has led to an increase in the frequency, intensity and or amount of heavy precipitation events at the global scale (medium confidence), as well as an increased risk of drought (Hoegh et al., 2018). In the province of Central Java, Indonesia, there were also areas that experienced an increase in rainfall and a decrease from 2009-2018 was observed. This is happens globally, future rainfall in Tanzania, East Africa was also predicted to decrease by 12%–37% in April, May, June and July, while rainfall in the remaining months, was predicted to increase by 3%–58%. (Shagega et al., 2019). In the Mediterranean region, climate change also expected to lead to large drought risks to primary productivity, according to six different vegetation models (Van Oijen et al., 2014) and confirming earlier analyses (Schröter et al., 2005). Zhang et al. (2017) stated that a warming and drying climate caused a decrease in soil moisture of 11.2% during 1981-2014 in Northern China, and the drying trend in crop fields was more evident than that in grassland.

Table 2 Average annual rainfall in Central Java Province, Indonesia 2014 – 2018

Average Rainfall (mm year^{-1})	Category	Regional Coverage	Area (hectare)	Total (hectare)
500 – 1,000	Low	Kebumen, and in small area of Cilacap and Grobogan District.	4,153.87	804,255.82
1,000 – 1,500			65,740.79	
1,500 – 2,000			734,361.16	
2,000 – 2,500	Medium	Brebes, Cilacap, Tegal, Tegal City, Banyumas, Purbalingga, Pemalang, Pekalongan, Batang, Kendal Semarang, Semarang City, Demak, Sragen, Boyolali, Salatiga City, Surakarta City, Karanganyar, Sukoharjo, Klaten, Wonogiri, Purworejo.	735,111.11	2,386,608.61
2,500 – 3,000			896,330.46	
3,000 – 3,500			456,924.50	
3,500 – 4,000			298,242.55	
4,000 – 4,500	High	Banjarnegara, Wonosobo, Temanggung, and some areas of the district of Magelang and Magelang City.	60,192.04	89,235.57
4,500 – 5,000			24,537.68	
5,000 – 5,121			4,505.85	
		Total (hectare)	3,280,100	

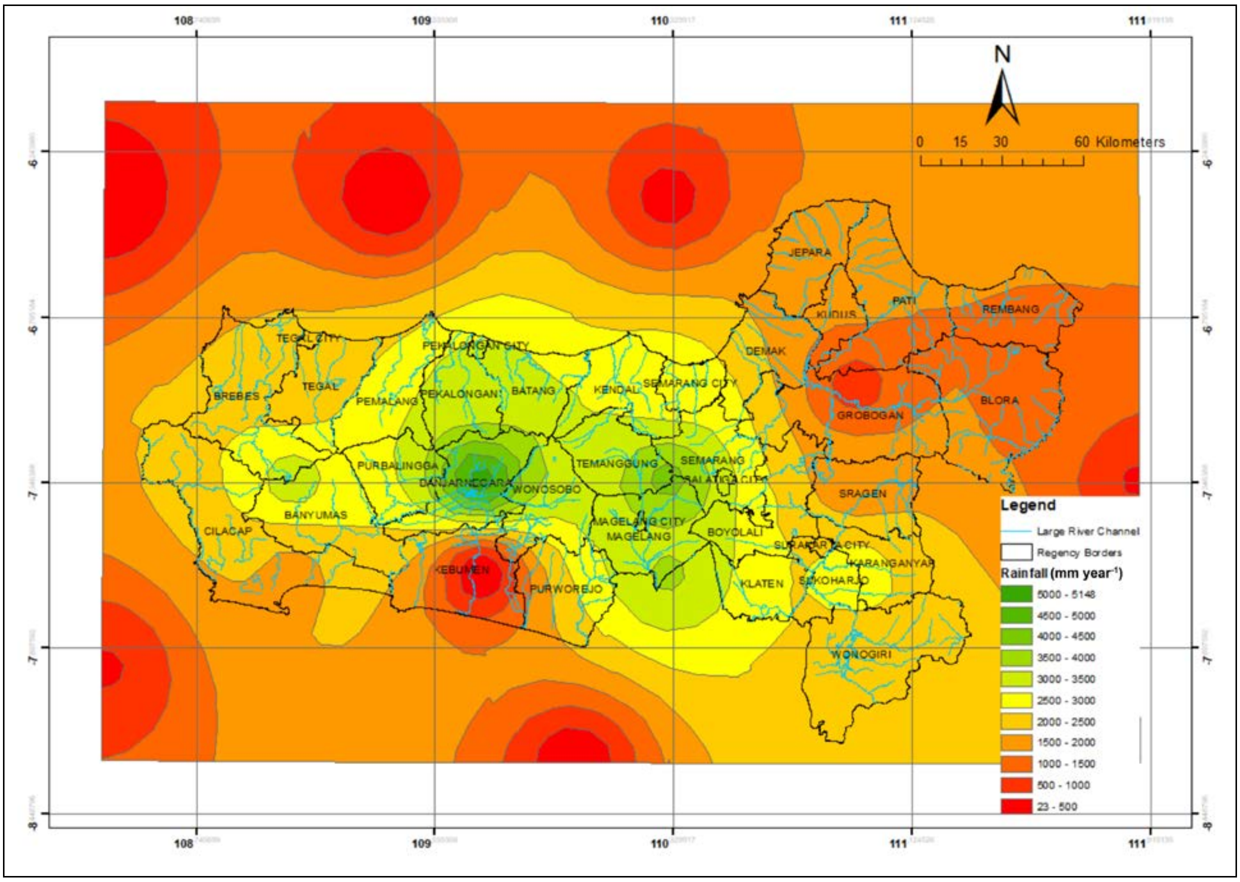

Figure 9 Annual average rainfall in Central Java, Indonesia 2019 – 2023

The highest rainfall in central Java in 2019-2023 was in the central area, and the rainfall was decreased towards the east, south, west, north and there was a drastic reduction in rainfall in the south (Kebumen Regency) and northeast (Grobogan Regency). The pattern was still the same up to the ocean area, in the Java sea, rainfall is decreasing to the southwest, northwest, and northeast but there was a decrease in rainfall quite high at several points, in the Figure 8, seen a few new red dots. Generally, the rainfall pattern in 2019-2023 still had the same pattern as the previous 5 years but there was a drastic reduction in rainfall in some areas up to 23-500 mm year^{-1}. In 2019-2023, areas that have low rainfall or around 23-2,000 mm year^{-1} covered an area of 1,064,777.55 hectare (32.46%), increased by 7.94% from the last 5 years. Areas with medium rainfall or around 2,000-4,000 mm year^{-1} covered an area of 2,149,996.61 hectare (65.55%), decreased by 7.21% from the last 5 years. Areas with high rainfall, or around 4,000-5,148 mm year^{-1} covered an area of 65,325.83 hectare (1.99%), decreased by 0.73% from the last 5 years. Details of the area with the amount of rainfall can be seen in Table 3.

Some regencies in Central Java (Banjarnegara, Klaten, Grobogan, Pemalang, Kebumen, Boyolali and Wonogiri) were in the status of a drought emergency (Wibowo, 2019). Based on data from the BPBD of Kebumen Regency, there were affected at least 85 villages spread across 16 sub-districts in the Kebumen Regency. Karanggayam sub-district was the worst affected with 12 villages experiencing clean water crisis, followed by Ayah sub-district with 11 villages and Pejagoan sub-district nine villages (Marzuki, 2019). This information is in accordance with the predicted rainfall data in 2019-2023, where Kebumen and Grobogan and surrounding areas have very low rainfall resulting in drought.

Table 3 Average annual rainfall prediction in Central Java Province, Indonesia 2019 – 2023

Average Rainfall (mm year^{-1})	Category	Regional Coverage	Area (hectare)	Total (hectare)
23 - 500	Low	Kebumen, Grobogan, Kudus, Sragen, Blora, Rembang, Pati, Jepara, and parts of the region of Cilacap, and Demak.	18,852.45	1,064,777.56
500 – 1,000			57,641.61	
1,000 – 1,500			403,970.10	

1,500 – 2,000			584,313.39	
2,000 – 2,500	Medium	Banyumas, Purbalingga, Cilacap, Brebes, Tegal, Tegal City, Pemalang, Kendal, Pekalongan, Pekalongan City, Batang, Wonosobo, Temanggung, Magelang, Magelang City, Semarang, Salatiga City, Boyolali, Klaten, Wonogiri, Sukoharjo, Karanganyar, Surakarta City	869,056.47	2,149,996.61
2,500 – 3,000			678,401.84	
3,000 – 3,500			469,787.83	
3,500 – 4,000			132,750.47	
4,000 – 4,500	High	Banjarnegara, Salatiga City and parts of the region of Wonosobo, Temanggung, Magelang and Semarang	39,836.47	65,325.83
4,500 – 5,000			20,491.95	
5,000 – 5,148			4,997.42	
		Total (hectare)		3,280,100

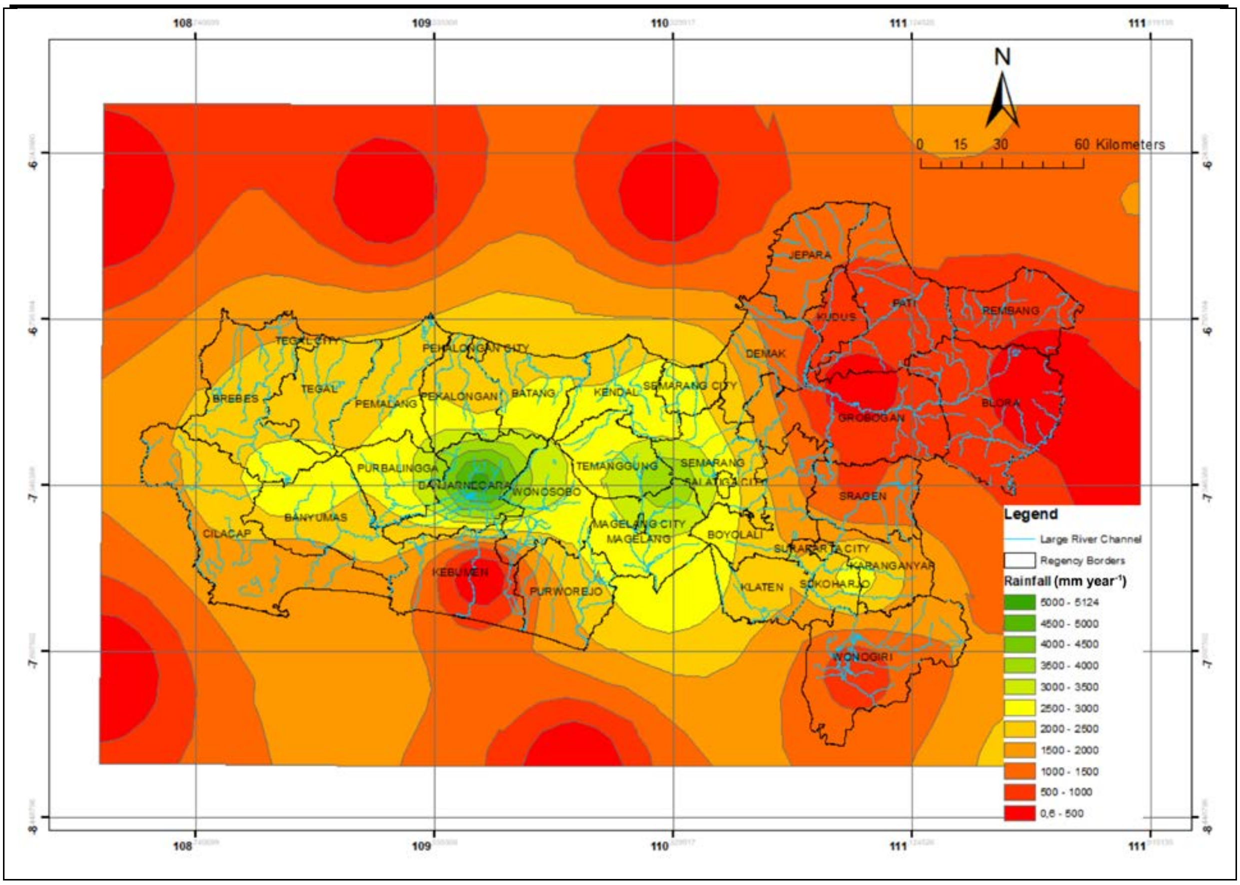

Figure 10 Annual average rainfall in Central Java, Indonesia 2024 – 2028

In 2024 - 2028, it is predicted that there will be a decrease in rainfall which is quite high compared to the previous 20 years in the Java and Indian Ocean areas (Figure 10), in 2009 the area had a rainfall of around 2,500 mm year^{-1} and in 2028 it became around 500 mm year^{-1}, decreased about 2,000 mm year^{-1}.

The highest rainfall in central Java in 2024-2028 (Figure 10) still was in the central area, and the rainfall decreased towards the east, south, west, and north, showing a drastic reduction in rainfall in the south (Kebumen Regency), northeast (Grobogan Regency), and southeast (Wonogiri Regency). The pattern was still the same up to the ocean area. In the Java sea, rainfall is decreasing to the southwest, northwest, and northeast, but there is a decrease in rainfall is quite high at several points, in the Figure 10 seen a few new red dots which is broader compared to the last 5 years (Figure 9). Generally, the rainfall pattern in 2024-2028 still had the same pattern as the previous 5 years but there was a drastic reduction in rainfall in some areas up to 0,6-500 mm year^{-1} or there was no rain at all in one year. In 2024-2028, areas that had low rainfall or around 0,6-2,000 mm year^{-1} covered an area of 1,615,125.2 hectare (49.24%), increased by 16.78% from the last 5 years. Areas with medium rainfall or around 2000-4000 mm year^{-1} covered an area of 1,620,593.42 hectare (49.41%), decreased by 16.14% from the last 5 years. Areas with high rainfall, or around 4,000-5,124 mm year^{-1} covered an area of 44,381.36 hectare (1.35%), decreased by 0.64% from the last 5 years. Details of the area with the amount of rainfall can be seen in Table 4.

The IPCC Special Report on Climate Change and Land stated that average temperature over land for the period 2006–2015 was 1.53°C higher than for the period 1850–1900, and 0.66°C larger than the equivalent global mean temperature change. In addition to an increase in temperature, changes in rainfall patterns also occur, which showed the same as the results of the analysis that has been done and can be seen in the Figure 7 to Figure 10. These warmer temperatures (with changing precipitation patterns) have altered the start and end of growing seasons, contributed to regional crop yield reductions, reduced freshwater availability, and put biodiversity under further stress and increased tree mortality (Shukla et al., 2019). In China, it is also projected that there will be greater drought and a longer duration in the years 2021-2050 due to climate change (Gu et al., 2019) and can lead to negative effects/ decreasing on crop yield and higher virtual water content particularly in the far future e.g. the 2090s (Zhao et al., 2014). Based on the results, rainfall data prediction can be done by ANFIS modeling, and have a good value and can represent the actual environment. So that ANFIS modeling can continue to be used and developed for the prediction of other climate parameters (Klemm and McPherson, 2017).

Table 4 Average annual rainfall prediction in Central Java Province, Indonesia 2024 - 2028

Average Rainfall (mm year^{-1})	Category	Regional Coverage	Area (hectare)	Total (hectare)
0,6 - 500	Low	Kebumen, Jepara, Pati, Rembang, Kudus, Grobogan, Blora, Sragen,and parts of the region of Purworejo, Cilacap, Banyumas, Brebes, Wonogiri, Karanganyar and Demak.	162,616.06	1,615,125.21
500 – 1,000			562,077.64	
1,000 – 1,500			397,299.32	
1,500 – 2,000			493,132.19	
2,000 – 2,500	Medium	Purbalingga, Karanganyar, and the other covers Banyumas, Cilacap, Brebes, Tegal, Tegal City, Pemalang, Pekalongan, Pekalongan City, and Batang.	820,410.64	1,620,593.43
2,500 – 3,000			575,099.36	
3,000 – 3,500			160,571.65	
3,500 – 4,000			64,511.77	
4,000 – 4,500	High	Banjarnegara, Wonosobo, Temanggung, Magelang and Magelang City	23,495.62	44,381.37
4,500 – 5,000			17,315.32	
5,000 – 5,124			3,570.43	
		Total (hectare)	3,280,100	

Based on the IPCC Report on Impact, Adaption and Vulnerability of Climate Change, states that global climate change causes changes in rainfall and temperature increases. Increases in temperature and changes in rainfall patterns can cause changes in vegetation naturally and in the long-term will affect the hydrological cycle and water quality in the area. Furthermore, Projected increases in temperature and changes in rainfall patterns can increase malnutrition; disease and injury due to heatwaves, floods, storms, fires and droughts; diarrhoeal illness; and the frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone (IPCC, 2007). Climate change is a thing that is and will continue to confront us in the future. We must pay serious attention to this, because climate change has an impact on all sectors of human life and the nature sustainability.

4 Conclusions

Climate change is proven to have an effect on changes in rainfall patterns in Central Java Province, Indonesia. Prediction of rainfall values and patterns has also been successfully carried out using the Adaptive Neuro Fuzzy Inference System (ANFIS) model and has a value that can represent rainfall conditions/ actual conditions.

Rainfall in the province of Central Java in 2009-2013 can be classified into two categories: medium and high. Areas with medium rainfall cover an area of 26,962.06 km^2 (82.19% of the surface), and with high rainfall cover an area of 5,838.94 km^2 (17.81%). The period 2014-2018 was classified into areas with low rainfall (500-2,000 mm year^{-1}), medium (2,000-4,000 mm year^{-1}), and high (4,000-5,121 mm year^{-1}). Areas that have low rainfall cover an area of 8,042.56 km^2 (24.52%). Areas with medium rainfall cover an area of 23,866.09 km^2 (72.76%), decreased by 9.43% from the last 5 years.

Areas with high rainfall covered an area of 892.36 km^2 (2.72%), decreased by 15.09% from the last 5 years. Predicted of rainfall in 2019-2023, areas that have low rainfall or around 23-2,000 mm $year^{-1}$ covered an area of 10,647.78 km^2 (32.46%), increased by 7.94% from the last 5 years. Areas with medium rainfall or around 2,000-4,000 mm $year^{-1}$ cover an area of 21,499.97 km^2 (65.55%), decreased by 7.21% from the last 5 years. Areas with high rainfall, or around 4,000-5,148 mm $year^{-1}$ cover an area of 892.36 km^2 (2.72%), decreased by 0.73% from the last 5 years. And predictions in 2024-2028, areas that have low rainfall or around 0.6-2,000 mm $year^{-1}$ cover an area of 16,151.25 km^2 (49.24%), increased by 16.78% from the last 5 years. Areas with medium rainfall or around 2,000-4,000 mm $year^{-1}$ cover an area of 16,205.93 km^2 (49.41%), decreased by 16.14% from the last 5 years. Areas with high rainfall, or around 4,000-5,124 mm $year^{-1}$ cover an area of 443.81 km^2 (1.35%), decreased by 0.64% from the last 5 years.

Overall, it is predicted that from 2009 – 2028 in the Province of Central Java, Indonesia will experience a decrease in high rainfall in an area of 16,151.25 km^2 or around 49.24% / almost half of the province experiencing a decrease in high rainfall and can cause drought. These areas include Kebumen, Jepara, Pati, Rembang, Kudus, Grobogan, Blora, Sragen, and parts of the region of Purworejo, Cilacap, Banyumas, Brebes, Wonogiri, Karanganyar and Demak.

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