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Rain-gauge Network as the Basis of a Model to Predict the Beginning of the Planting Season in Facing Climate Change Effects. Case Study in the Kranggan Village, Sub-district of Pekuncen, Banyumas Regency

Djoko Harmantyo*, Eko Kusratmoko, Sobirin

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*Corresponding author: djoko.harmantyo@ui.ac.id

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Abstract Climate change is expected to affect agriculture in Southeast Asia, including in Indonesia in several ways. Temporal and spatial changes of rainfall which resulted in a shift in the early of the season indicate one of the climate change phenomenon. Early rainy season turned erratic causing no certainty the time of planting. Farmers suffer losses because the plant can produce not well. Daily rainfall data in a full year observation can be used to show when the beginning planting season. The purpose of this study firstly is to find the difference between the amounts of rainfall in different density of rain gauge. Secondly is to find variations in the spatial pattern of rainfall in different density of rain gauge. Total amount of rainfall observed data in tens day, namely dasarian rainfall, from July until December 2014 to be tested using Mann-Kendall method and by ANOVA. Rainfall data is processed by Arc-GIS software presented in a map to show variation of the rainfall spatial pattern. The research results showed that average of amount of the rainfall over the same areas is significantly difference between high rain-gauge density and low rain-gauge density. Shifting the early of the rainy season occurs about two weeks up from the general pattern of rainfall on the last of October.

Keywords: *climate change, rain fall, rain-gauge density, beginning of rainy and planting season*

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1. Introduction

One of the drivers of global climate change is the increase in the temperature of the earth. The increase in the average temperature of the Earth's surface since 1850 amounted to 0.76° + / _ 0.190°C and since the beginning of the 21st century is likely to increase more rapidly. This trend is predicted in the coming 100 years the temperature will increase by 2.4° - 6.4°C (Camilleri, 2009). The increase in temperature causes evaporation intensity increases and in turn will increase the intensity of the rain that falls to the earth's surface (Bruce, 1966). Characteristic parts of Indonesia as the biggest archipelagic country in the world, located on the equator and consists of 2/3 wide sea water level (Sandy, 1995), a place that meets the requirements to prove the theory. That is, the process of the ongoing global warming in general will lead to increasing precipitation that falls in the region of Indonesia (Susandi, 2007).

United Nations Conference on Climate Change (UNFCCC) in Copenhagen in December 2010 recommending one of important efforts to face the effects of global climate change is to investigate climate change in each country. Investigating climate change is directed primarily to provide a solution to people who are most vulnerable to climate change impacts especially the communities of farmers and fishermen. In addition to the catastrophic floods that hit agricultural areas due to very heavy rainfall as one of extreme weather phenomena, shifting seasons can also result in crop failure. Investigation season changes or shifts in the sub District of Maos in Cilacap Regency is in the category of research activity recently (Harmantyo, 2013).

There are at least two opposite condition due to the increased precipitation that falls in a region. The first condition, the amount of precipitation that more will increase the potential of water resources so as to increase the productivity of the results of the use for irrigation, power generation, rain fed especially the agriculture, industry and domestic use. Two conditions to the contrary, a large amount of rainfall and occurs continuously within a few days will cause major flooding in the lowlands along the river, river embankments and reservoirs breakdown, and landslides in various places that has a slope more than forthy percent. The impact of major floods and landslides will be a disaster for causing huge losses including the loss of lives. The flood that inundated farmland population will result in damage to rice crops so that farmers productivity decline, even to the extent of crop failure. In the long term this condition can interfere with national food security.

As the change of rainfall intensity, an indication of the effect of climate change is also indicated by the change of seasons or the shifting seasons. Time erratic rainy season and does not happen as usual, as the knowledge of local farmers. The farmers do not have guidance on when it is appropriate to begin to grow rice so frequent crop failures. This will affect the income of farmers due to reduced rice production. In aggregate these circumstances would clearly interfere with national food security.

Methods for analysis of the variability of rainfall have been carried out. However, in the local scope, rainfall variability analysis results for the purposes of early season prediction using empirical data rainfall measurement results, especially in the area of study has never been performed. This study is not only to find answers "scientific questions" but also to simultaneously perform the application of research results in addressing the issues facing the community directly. The community is involved directly in the research process so that people gain the knowledge to be the provision of independent activity in the future.

Beginning of the rainy season is always changing due to changing of climate. Such changes cause uncertainty farmers have time to start planting rice. The availability of accurate rainfall data in real time is needed in the planning and activities of rice cultivation. Accuracy of data is determined by the number density of the rain gauge. A study of rainfall data from the various meteorological stations (RG) in Java has been done since the early 1980s (Harmantyo, 1983). In these studies illustrate the opportunities gained rain water associated with the periods to planting rice and pulses. Some interesting findings from the study is that not all the rain that is a graduated running well or can be called as damaged.

Rainfall data reported errors encountered even be referred to as a data manipulation. Various factors to be the cause of the problem is partly due to the lack of supervision of authorized institutions, lack of understanding of the local government officials of the importance of rainfall data, lack of budgetary support escpecially from the Meteorology Climatology and Geophysic Agency. In addition, the rainfall data collected who have not performed adequately processing and analysis and therefore can not be used as feedback to evaluate the quality of the measurement of rainfall data. This raises implications not maximum utilization of existing data is rainfall for various purposes including for the purposes of planting guidelines.

Since the onslaught of climate change began in early 2000 has made the collection of data from various stations in Indonesia to study the behavior of the rain as the effects of global climate change on climate change in Indonesia. Based on data from the 1900s until 2008 (not all stations have complete data) it can be shown that there is a trend change in the pattern and amount of rainfall in Indonesia (Harmantyo, 2009). In the southern hemisphere the equator generally an increase in the number of rainfall was in the north of the equator in some places experiencing the opposite. The influence of the events of El Nino and La Nina as well as changes in sea surface temperature over the Indian Ocean variability dominant in the rain even though in certain places of local factors such as topography and distance from the sea is still dominant. Judging from the amount and distribution of rainfall stations (post rainy) of the data turned out to be at most the number of RG is in Java and outside Java are relatively few.

2. Methods

Analysis of climate change requires observational data for at least 30 consecutive years in the number of complete and accurate (Trewartha, 1954). Such data are difficult to obtain in Indonesia as the results of previous research authors. Therefore, an analysis of the changes that occur during the season requires additional effort is needed so that data can be more complete and reliable. Increasing the rain-gauge density is one of an alternative solution. According with World Meteorological Organization there is of nine hundred kilometer square per gauge in the plain area. In this research, experiments will be carried out in the smaller area that is each gauge in an area of a hundred kilometer square, of four kilometer square and of two and half kilometer square. Rain-gauge type of Ombrometer and homemade instrument were used to measuring daily rainfall directly in this study.

Accuracy of data is determined by the number density of the rain gauge. To mountains area with irregular rainfall recommended 25 km^2 per gauge, 4km^2 per 6 gauges in United Kingdom, Hongkong and about 1000 km^2 per gauge in Uganda. According to WMO guidelines its density is 10-20 km^2 per gauge in urban areas. In this study uses of 30 pieces of rain-gauges consisting of 13 Ombrometer located in Pekuncen Sub-District and of 17 homemade rain gauges located in Kranggan Village. Each gauge location designed by grid system network. Total amount of rainfall observed data in tens day, namely dasarian rainfall, to be tested using Mann-Kendall method and by ANOVA. Rainfall data is processed by Arc-GIS software presented in a map to show variation of the rainfall spatial pattern of of each gauge density.

3. Result and Discussion

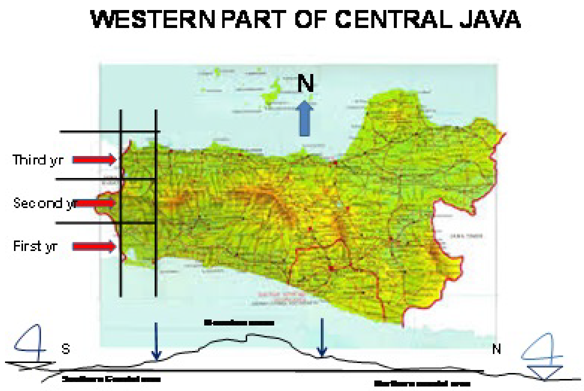

Figure 1. Area of the study in Central Java Corridor

Following this line of thought above, the amount of precipitation that falls in the district of Banyumas has variations both spatially and temporally. Changes in the amount of precipitation affect to both of monthly and annual rainfall patterns. The rate of change varies according to the amount of rainfall, altitude and location because of the distance from the coast, the position of the face of the slope and altitude are local factors that affect the local climatic conditions (Trewartha, 1954, Sandy, 1987, Linacre, 1997, Strahler, 2003, Harmantyo 2009, IPCC, 2012). Change in precipitation globally influenced by El Nino and La Nina and southern oscilation-indexs.

If it can be precisely known and the pattern of rainfall variability trend of change or shift in season it will be able to predict the arrival time at the beginning of the rainy season. If the beginning of the rainy season it can be seen that farmer can plan the planting and harvest as well as to estimate the level of rice production so as to participate in maintaining national food security. If the results of this study showed indications that the general alignment between the model and the actual observed data, this research can be developed in various regions across Indonesia. As the start of the study has been taken in the study site Cilacap district in 2013.

Map of administration boundary of Banyumas Regency, Pekuncen sub-district and Kranggan village shown in Figure 2 and Figure 3.

Based on rainfall data from 1980-2012 can be shown generally the beginning of the rainy season occurs in the last of September in both of Cilacap Regency and of Banyumas Regency but the beginning of the dry season occurs in the mid of Mei in Cilacap Regency and of the early of June in Banyumas Regency. See Figure 4.

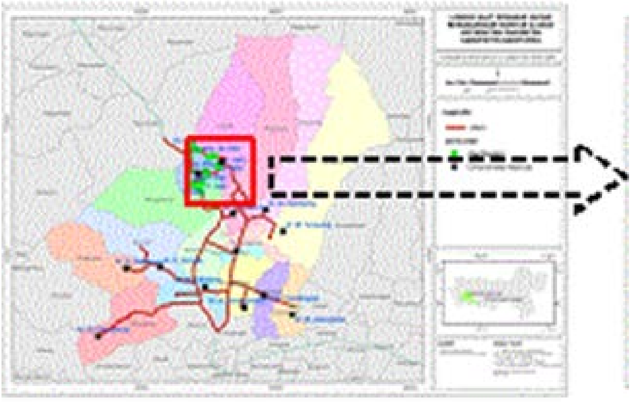

Figure 2. Pekuncen sub-district location

Figure 3. Kranggan village location

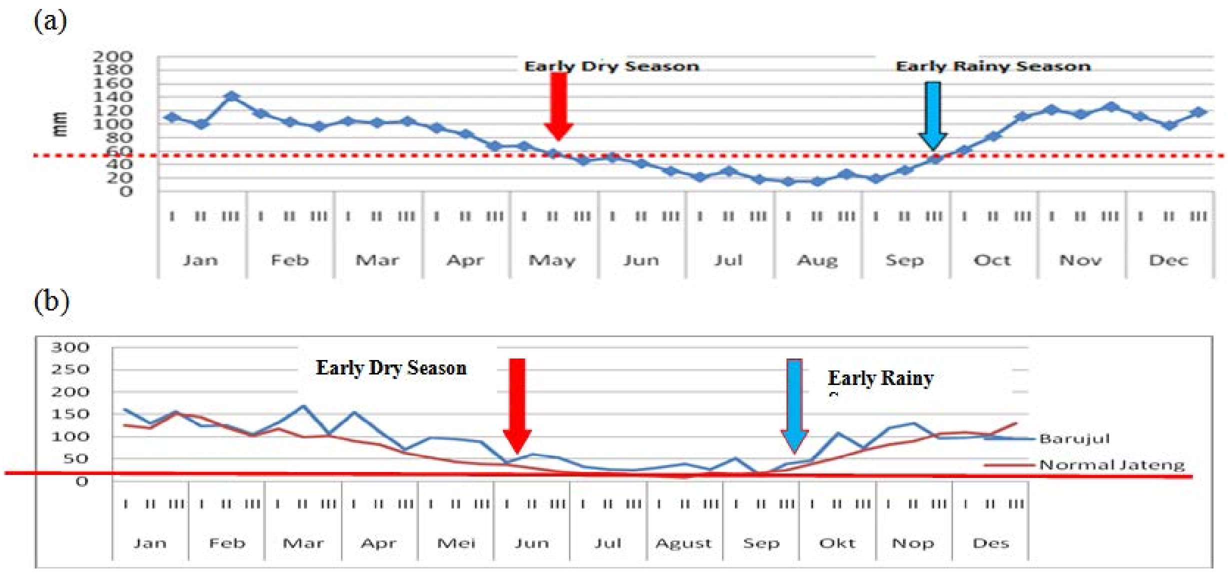

Figure 4. Pattern of temporal rainfall (a) the Cilacap meteorological station and (b) the Barujul (Banyumas) meteorological station.

Monthly rainfall data of the study area between 1981-2012 to be examined by Mann-kendall is shown in Table 1 and Figure 5 below.

Table 1.

Rainfall (mm/10's days)					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	465347.218	8	58168.402	249.750	.000
Within Groups	35634.699	153	232.907		
Total	500981.917	161			

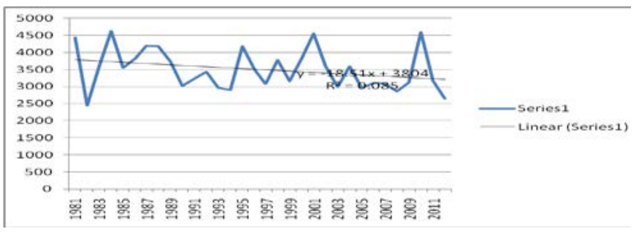

Figure 5. Mann-kendall linear regression coefficient of monthly average rainfall in Banyumas Regency from 1981-2011.

Table 2.

	Software: Hydrospec		
No. ZOM	Significance level 95%	Note	Significance result
100	79.99%	down to 22,1 mm/year	< 95%: not significant
101	2.58%	Up to 3,1 mm/year	< 95%: not significant
102	25.43%	Down to 4 mm/year	< 95%: no significant
103	95.39%	Up to 23,9 mm/year	> 95%: significant
105	94.43%	Down to 18,5 mm/year	< 95%: no significant
106	2.58%	Up to 4 mm/year	< 95%: no significant
107	78.22%	Down to 12,5 mm/year	< 95%: no significant

In contrast to the rainfall data for 30 years above then the direct measurement obtained more detailed data of rainfall. Although the rainfall data is not yet complete but based on the existing data can be shown early indications of the rainy season in 2014. See Figure 5a.

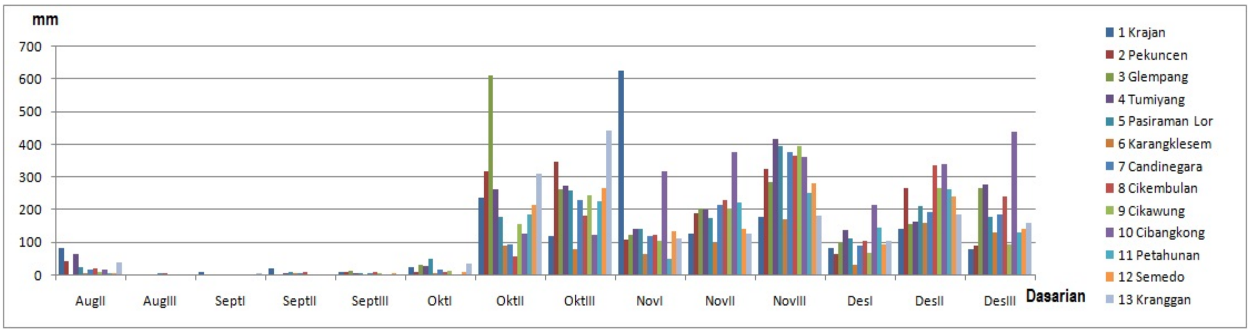

Figure 5a. Dasarian rainfall distribution each gauge location in Pekuncen Sub-district in 2014.

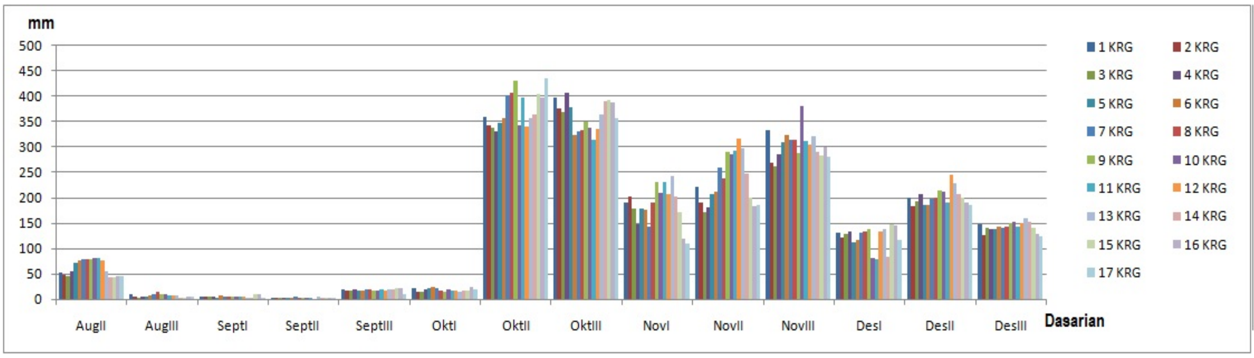

Figure 5b. Dasarian rainfall distribution each gauge location in Kranggan Village in 2014.

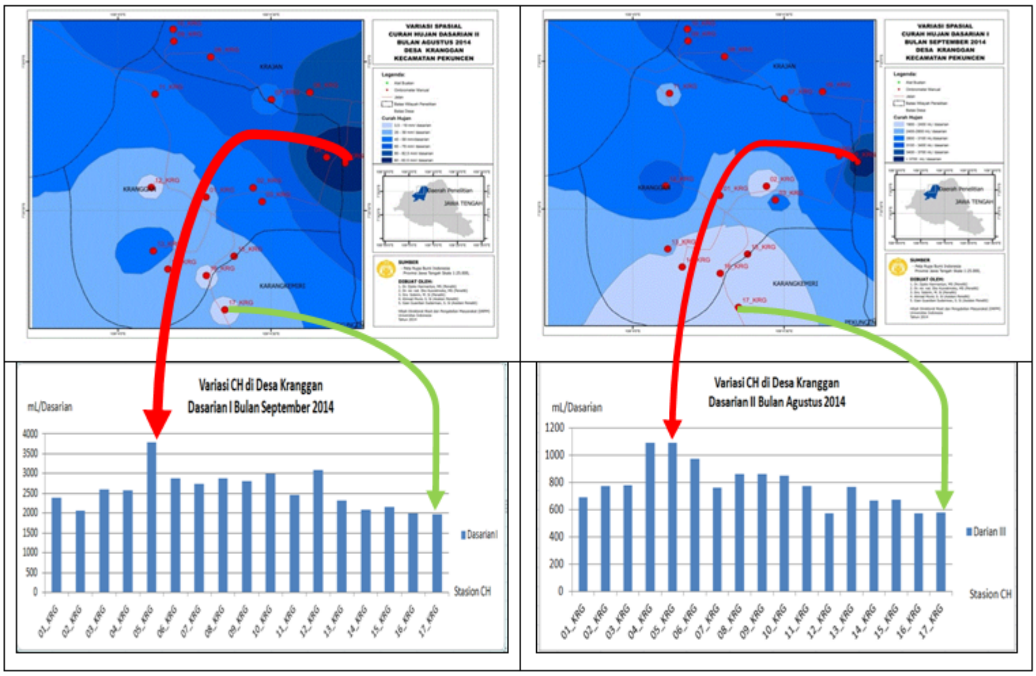

Figure 6. Daily rainfall of dasarian in August and September 2014 in Kranggan village.

Although different in rain gauge density the rainfall distribution patterns tend to be similar but otherwise an amount of rainfall per hectar is significantly different.

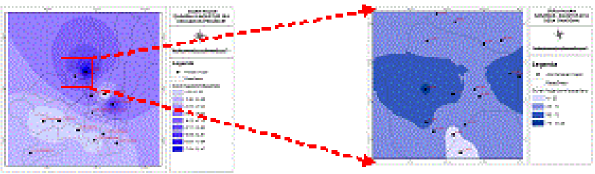

Figure 7. Rainfall pattern in dasarian 2^{sd} August 2014

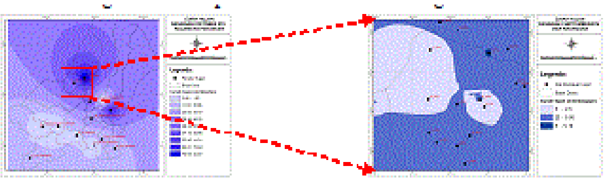

Figure 8. Rainfall pattern in dasarian 2^{sd} October 2014

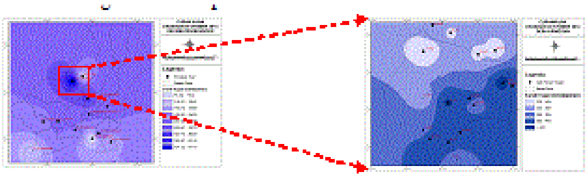

Figure 9. Rainfall pattern in dasarian 2th October 2014

4. Conclusion

Topographic factors likely to affect the pattern of rainfall in this area. The spatial pattern of rainfall shows the variation in space and time. The results show the amount of rainfall over an area of 100 x 100 square meters to be significantly different between high density and low density. The amount of rainfall measured in a high density more accurately and precisely. The beginning of the rainy season and dry season can not be shown in full for the measurement of rainfall data has not been completed. Based on the available data there appears to be a shift in the trend slightly

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