Development of High Resolution Planting Calendar Map to Increase of Rice Productivity in Indramayu

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Abstract. *The higher population growth led to increasing of national food needs, so that food security is one of the present and future national priorities. In satisfying one of the basic needs, the government is now faced with the problem of agricultural failure each year, including the failure of rice planting and harvesting that has led to a decrease in productivity of 20%. Both failures are almost always caused by changes in weather patterns and climate in which farmers cannot properly plan activities during planting and harvest. That is because the coming of the rainy season at the moment cannot be expected to be business as usual. To that end, the role of technology in correctly modeling and rainfall predicting (high resolution) becomes very important.*

This study is aimed to build high resolution planting calendar to estimate the initial time of rice planting in Indramayu to increase rice productivity. ***Fast Fourier Transform*** *method is used to split rainfall time series data into the sub data based on the periodic characteristics. Then, using* ***Least Square non-linear****, the more accurate function of model can be obtained. Both methods are used to built the prediction of rainfall. Since rainfall data are not linear, it must be built using a non-linear model as well. Spatial map of rice planting estimation was produced by overlaying maps of the rainfall prediction result and the rice field in Indramayu.*

Keywords: *fast fourier transform, high resolution, least square non-linear, rainfall prediction, rice planting time, rice productivity*

1 Introduction

Global climate change has made the instability of the atmosphere, especially in Indonesia as a country where is in the tropics area. The impact of climate change may affect the dynamics of the atmosphere and the resulting increase in certain phenomena such as El Niño-Southern Oscillation (ENSO). Analysis of historical data shows that the variation in the recent El Niño is most likely linked to global warming.

Patterns of climate variability, especially El Niño-Southern Oscillation (ENSO), has been used in numerous studies to estimate the impact of food and agriculture. The atmospheric dynamics can affect the timing of rice planting, crop, farmers' income, and prices of agricultural products at local to global scales (Naylor et al., 2007). Major food crop for 218 million citizens of Indonesia are very dependent on the timing and amount of rainfall throughout the year and therefore climate variability will greatly affect the security and national food security. (BPS, 2011)

Adaptive capacity of small farmers to climate variability or extreme climate events is still relatively low. Farmers always apply agricultural planning system based on the assumption of normal rainfall, especially in areas with limited irrigation infrastructure systems. Each ENSO phenomenon, the farmers in the district are always affected and followed by a significant decline in agricultural production. They are not able to anticipate the occurrence of floods and droughts better. As a result, farmers suffered losses in agricultural production and incomes. Because of this impact, agriculture in rural Indonesia is difficult to increase agricultural productivity better than ever. Due to the time change rainfall data, it is difficult to predict farmers planting rice as usual. In the event of extreme weather, it will aggravate the condition more difficult to plan agricultural and during planting and harvesting.

2 Data and Methodology

2.1 Data

To get estimation of the future climate predictions for the rice planting on a agricultural field, the required data are the daily rainfall data that were obtained from a meteorology monitoring station in Indramayu during the past 25 years. The rice field maps is also required to estimate the rice planting time in spatial scale. Daily rainfall data is used to obtain rainfall prediction in *dasarian* (ten days).

2.2 Development of Smart Climate Model

To produce estimates of planting rice based on the prediction of rainfall, the climate models is the first thing to perform. Smart climate model is a model that can be implemented to predict and associated with the phenomenon of climate variability to take the periodic values of climate events. Models is made to make quantitative predictions (deterministic or probabilistic), which can be used to test and refine the previous model, or for practical use (Howison, et al., 2005).

Therefore, one of the stochastic model has been used in this research, a model that combines the Non Linear Least Square method and Fast Fourier Transform. Both methods are actually commonly used by researchers to analyze and climate prediction. However, in this study, there is the development of one of the mathematical function used, which is a function of Fourier series. The sequence of rainfall data is modified to a series that is not linear as in equation (1). It is possible that the function can follow the rainfall variability that is not linear.

$$a_0 + \sum a_i x \sin(iwx) + \sum b_i \cos(iwx) + f(x) \quad (1)$$

Fourier analysis is an important tool in this analysis of climate data. The aim is to illustrate the character of periodic climate data using a combination of sinusoidal components with different frequencies. The amplitude and phase of each component in the sequence determine the contribution of the frequency components being relative to the overall data.

To develop climate models using Fast Fourier Transform, rainfall data will be the input models and climate prediction (Susandi et al, 2008), which measures the model that are described as follows. To produce a good prediction, this model requires 3 steps of analysis, namely the analysis of the initial prediction, anomaly analysis and analysis of periodic character. All three methods are used to correct for the prediction of each other so that the resulting prediction results are more accurate and stable. These measures are based on the inversion method to obtain the best model (Aster et al., 2005)

(i) initial prediction model

Rainfall data for the locations is analyzed by least squares to generate the corresponding fitting curves. The selected equation is a modified Fourier series in such a way as to be compatible with the rainfall data.

(ii) analysis of anomalies Model

The analysis is performed to track the rainfall changes so that the trend of climate change itself can be identified. To get the data changes, the data field will be reduced by the average data of rainfall. The result of this reduction produces data with high enough noise to analyze it directly that would give the higher deviation error. Because of the steps of this research focuses on tracking of trend data changes, the data can be filtered to remove noises using the Kalman Filter method. This method was chosen because (unlike the data smoothing method that is only good for mid filter data) this method can filter the data from the beginning to the end of the data perfectly. The results of this filter will be further analyzed using curve fitting analysis as a first step so as to provide rainfall trend change that will be used in the correction of previously predicted data.

(iii) Analysis of the nature of the periodic

Periodic character of the data analysis is conducted to inform a recurrence of a large-scale rainfall deviation that is allegedly caused by a natural phenomenon, such as La-Nina and El Nino. Fast discrete Fourier Transform is used to convert the time domain rainfall data (time series) into rainfall frequency data. Significant changes to the specified period will be selected manually to input the data as a correction within a long term.

According Suprihatno, et al. (2008), the normal growth of plants requires a rainfall of 200 mm / month, but actual rainfall of 100 mm / month plant can still grow well although not as good as the rainfall conditions. To make a map of the early planting production in an area, it is necessary to map rainfall issued by climate change models. This map will then be overlaid using Geographic Information Systems method to map the distribution of rice obtained from the Department of Agriculture.

From the results of dasarian rainfall prediction, it can be used to determine rice planting time in Indramayu. Based on the results of crop modeling study conducted by Surmaini, et al. (2012), if the threshold of rice yield to be achieved is 5 tons / ha, rainfall that is needed during the growing season is 400 mm or about 35 mm / dasarian in the irigated rice field, while in the non-irrigated rice fields is 50 mm / dasarian. With this reference, it is obtained some estimates of planting rice in Indramayu district for the period 2013.

2.3 Result and Discussion

Figure 1 and 2 show one of the estimation of rice planting time in the district of Anjatan for the period of the dry season of 2013. It appears that the 2nd dasarian of April 2013, the districts will be ready to plant rice in Anjatan. The estimates are resulted from the rainfall amount on dasarian 1 and 2 that are already qualified to start planting rice. Total of rainfall at dasarian 1 and 2 are 140 mm (Figure 1). If you look at the amount of rainfall in next dasarian, it is predicted that the growth of the rice plant will be effective during the growing season up to 6 months. To that end, rice production forecast that is based on the results of crop modeling show that rice production will be at least 5 tons / ha.

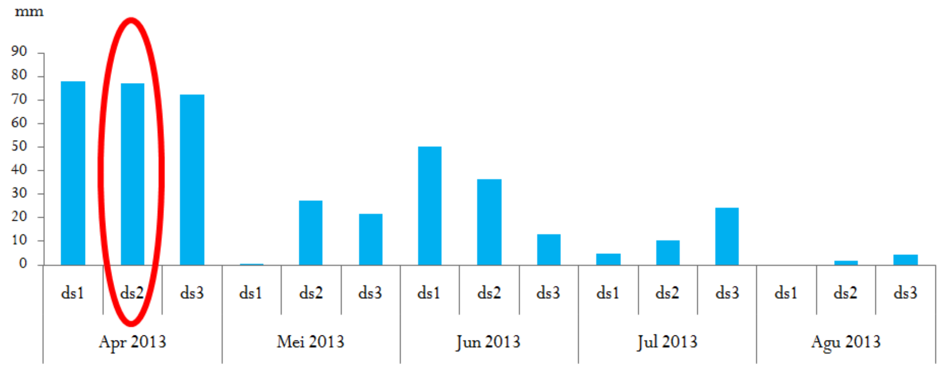

Figure 1 Prediction of rice planting time in dry season (MK) of Anjatan in 2013

For the rainy season (MH), the Anjatan is expected to start rice planting in dasarian 2 of November 2013. This is determined from the amount of rainfall at dasarian 1 and 2 in November 2013 with the amount of rainfall of 160 mm (Figure 2).

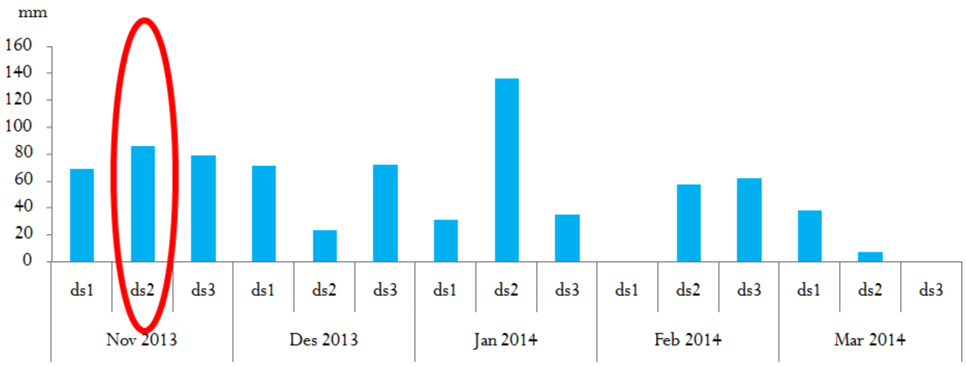

Figure 2 Prediction of rice planting time in rainy season (MH) of Anjatan in 2013

Here are the spatial map of planting rice estimation in the district of Indramayu. This estimated time is devoted to rice planting in period of 2013, namely the plant in the rainy season 2013, called the MT 1 and planting in the dry season of 2013, called the MT 2 (Figure 3 and Figure 4).

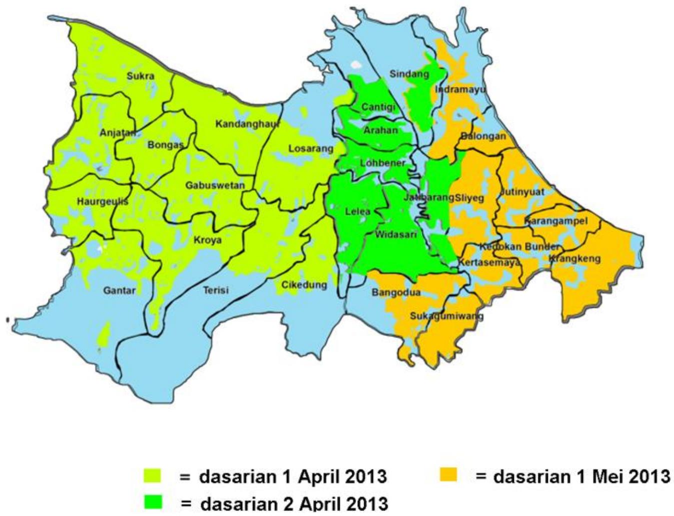

Figure 3 Prediction map of rice planting time in dry season (MK) of Inframayu in 2013

Figure 3 show the rice planting time in the dry season (MK) in 2013. In the dry season, the district is divided into 3 regions of planting time. At dasarian 2 in April 2013, the beginning of the rice planting can be conducted in Sukra, Bongas, Anjatan, Kandanghaur, Gabuswetan, Losarang, Cikedung, Kroya, Haurgeulis, Gantar and Terisi. At dasarian 2 of April 2013, the region that can start planting are Lelea district, Widasari, Lohbener, Arahan, Cantigi and Jatibarang. In dasarian 1 of May 2013, the region that can start planting are Bangodua, Sukagimawang, Kertasemaya, Kedokan Bunder, Krangkeng, Karangampel, Jutinyuat, Balongan and Indramayu.

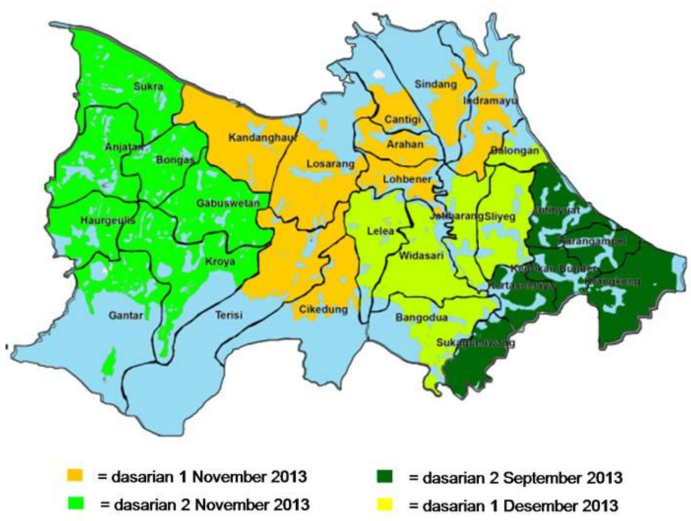

Figure 4 Prediction map of rice planting time in rainy season (MH) of Inframayu in 2013

For rice planting during the rainy season of 2013 can be seen in Figure 4. In the rainy season, the district is divided into 4 regions of planting time. In dasarian 2 of September 2013, the beginning of the rice planting can be done to Sukagimawang, Karangampel, Krangkeng, Kertasemaya, Jutinyuat, and Kedokan Bunder. In dasarian 1 of November 2013, the region that can start planting are Sukra, Anjatan, Bongas, Haurgeulis, Gantar, Kroya, and Gabuswetan. As for the dasarian 2 of November 2013, the region that could begin planting the district Cikedung, Terisi, Losarang, Kandanghaur, Lohbener, Arahan, Cantigi, and Indramayu. In dasarian 1 of December 2013, the area that can plant rice are Lelea, Bangodua, Widasari, Jatibarang, Sliyeg, and Balongan.

3 Summary and Recommendation

Based on the results of the analysis, some conclusions can be outlined as follows: (1) rainfall prediction results indicate that rainfall in the district of Indramayu will be predominantly caused by local factors, namely differences in land and sea, particularly in the north of Indramayu, and (2) the early planting of rice in Indramayu district is generally done after the rainfall accumulation for 2-3 dasarian.

Furthermore, the proposed policy recommendations of this research is to develop climate models to meet the needs of farmers in the district of Indramayu. Development can be done by making plans of socialization about rainfall prediction system for the determination of planting rice, in the form of information systems that are easy to use and understood by the farmers in the district Indramayu.

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