Information System of Rice Planting Calendar Based on Ten-Day (*Dasarian*) Rainfall Prediction[1]

Armi Susandi[1, a)], Mamad Tamamadin[2,b)], Erizal Djamal[3,c)], Irsal Las[4,d)]

[1)]Department of Meteorology, Institut Teknologi Bandung
Labtek XI Building floor 1, Jalan Ganesa 10 Bandung 40132

[2)]Laboratory of Applied Meteorology, Institut Teknologi Bandung
Ged. Labtek XI lt. 1, Jalan Ganesa 10 Bandung 40132

[3)]Center for Agricultural Technology Transfer Management, Ministry of Agriculture
Jl. Salak No. 22 Bogor

[4)]Indonesian Agroclimate and Hydrology Research Institute, Ministry of Agriculture
Jl. Tentara Pelajar 1a Bogor 16111

a) Corresponding author: armi@meteo.itb.ac.id
b)mamadtama@meteo.itb.ac.id
c)erizal_jamal@yahoo.com
d)irsallas@yahoo.com

Abstract. This paper describes information system of rice planting calendar to help farmers in determining the time for rice planting. The information includes rainfall prediction in ten days (*dasarian*) scale overlaid to map of rice field to produce map of rice planting in village level. The rainfall prediction was produced by stochastic modeling using Fast Fourier Transform (FFT) and Non-Linier Least Squares methods to fit the curve of function to the rainfall data. In this research, the Fourier series has been modified become non-linear function to follow the recent characteristics of rainfall that is non stationary. The results have been also validated in 4 steps, including R-Square, RMSE, R-Skill, and comparison with field data. The development of information system (cyber extension) provides information such as rainfall prediction, prediction of the planting time, and interactive space for farmers to respond to the information submitted. Interfaces for interactive response will be critical to the improvement of prediction accuracy of information, both rainfall and planting time. The method used to get this information system includes mapping on rice planting prediction, converting the format file, developing database system, developing website, and posting website. Because of this map was overlaid with the Google map, the map files must be converted to the .kml file format.

Keywords: climate model, cyber extension, information system, rice planting, stochastic, ten-days rainfall prediction

INTRODUCTION

One of the farmer's main problems in agriculture activities is determining the accurate time to start planting. The determination depends on water availability coming from rain water. However recently, there is shipment of rain season time that could not be predicted by farmers due to impact of climate change. The condition makes difficulty for farmers and mostly causes failing to plan rice planting season.

Indramayu district is very vulnerable to decrease in productivity of rice, due to failure in determining the rice planting time. The decline of rice production is more dominant due to changes of weather and climate patterns. Farmers have failed on average 5-6 times that costs USD 70 per ha (USD 350 - USD 420 per planting season). The condition is exacerbated by the inadequacy of irrigation water sources. Floods and droughts have huge impact on agricultural areas. Therefore, adaptation in rainfall patterns will reduce the loss risk of farmers. The role of technology development in modeling and prediction of rainfall with highly accuracy and resolution becomes very important.

This paper describes result of rainfall prediction and rice planting time as output of smart climate model [1] developed in 10-day scale. The prediction has been verified to the rainfall observation data using the approach of R-Square, R-Skill, and RMSE. After that, the prediction has been also mapped in spatial system using krigging (for rainfall) and thematic map (for rice planting). Using this maps, farmers and extension could utilize

[1] The 5th International Conference on Mathematics and Natural Science, November 2014

them to determine rice planting season by printing the maps to be a planting calendar system. This is the information that was also usually done by farmers in East Nusa Tenggara in implementing rice planting prediction in monthly scale [2]. However, the traditional system of information delivery should be developed to be modern system, such as web platform, in order to automatically update the prediction and get feedback on the predicted results for evaluation.

Recently, the ICT (the information and communication Technology) equipped by a web-based map with the high technology that could enable user to perform editing, such as overlaying with other supporting maps. Utilizing the technology, the result of rainfall and rice planting prediction could be applied to the web designed and developed reliably, easily accessible and understood for farmers, extensions and agriculture agency. Effective strategies and policies to promote the sustainable development of agriculture and the rural milieu require an information system to monitor and evaluate their implementation and impact and provide, in a timely fashion, continuous input for policymakers (analysts and authorities in the executive and legislative branches as well as the judiciary and leaders of other groups of stakeholders) on the evolution of agriculture [3].

To meet the web development need, the research utilize Google Maps since it support maps with file format .kml and .kmz where in this research the file format is implemented to rainfall prediction and rice field map. To build the agriculture-related information map on the Google Maps, various procedures corresponding building rainfall contour, converting maps, up to developing rice planting map should be conducted to obtain the web-based rice planting calendar.

DATA AND METHODS

To run the climate modeling, the data used includes rainfall data from 21 stations during 1979 to 2012 to produce rainfall prediction in ten-day scale in Indramayu. The smart climate model developed is an attempt to improve upon previous monthly-scale climate models [4] by introducing a ten-day scale that would enable farmers to more accurately plan their planting times based on water availability, especially in Indramayu, the main agricultural region in West Java. The smart model combines Least Square Non Linear analysis with a Fast Fourier Transform algorithm to produce predictions that are applied to rainfall in Java. Least Square Non-Linear analysis was selected for its accuracy, while Fast Fourier Transform was used to analyze the most influential climate phenomena in the region.

There are 3 main steps in the processing of the smart climate, namely initial model, anomaly model, and final model. The initial model utilizes the 5th Fourier series to fit the ten days rainfall data for initial model. The anomaly captured in the initial model is then filtered by Fast Fourier Transform (FFT) algorithm to be fit by the modified Fourier function (non-linear Fourier functions). This step (anomaly model) is the superiority of the climate model. And, the final step of this model is to combine the initial model and anomaly model to be an integrated model that has the highest accurate after verified using the observation data. The model then produces rainfall predictions for ten-day intervals. The model was validated using an R-skill that compares prediction with rainfall data observed at the same time and location. After that, all the predicted data was interpolated to gridded data using Krigging approach to produce rainfall contour for each ten-day rainfall package.

While map of rice planting time, it was developed using thematic approach by overlaying the temporal ten-day rainfall prediction. The condition should be met to determine what ten-day to be the date for starting plantation time. When the rainfall prediction and rice planting are mapped, subsequently they are built on the web page combined with Google maps.

As many Google web applications, Google maps also extensively use JavaScript. The aim of Google Maps API is to identify location, address finding, direction guide and so on. Almost everything related to maps use Google Maps technology to solve the problem. One example of Google maps utilization in agriculture implemented is providing information on risk or threat on the world’s plants that will be loss. The web-based interactive maps enable to provide a worthy clarification on plant profile and detail of plant species percentage that are potential to be loss in every country.

In this research, Google Maps become basic for taking informative maps (rainfall prediction and rice planting) in ten-day scale. Such all supported maps should be converted first to .kml to embed with the function compiled within the server. The .kml format file was chosen as it support in keeping the data including value, longitude and latitude information and database table id when it is being scripted in programming.

RESULTS AND DISCUSSION

These are results of rainfall prediction based on the historical data during 33 years in Indramayu. The results has been verified using R-square, R-skill, and RMSE approach as seen in Table 1 below. These verification was conducted in 2013 [1]. The experts generally stated that a higher correlation of 0.8 is the most good, and less than 0.5 is weak [5]. The highest R-square was obtained for Jutinyuat station, namely 0.82. R-skill indicates accuracy of the forward prediction model to the rainfall data in the same year. In this experiment, the rainfall data was tested to the 10-day predicted rainfall, where the highest R-skill is obtained for Bondan station reaching 0.82. RMSE was also considered to indicate the error of predicted rainfall value to the rainfall data. The lowest RMSE is obtained for Bondan station, about 31.23.

Tabel 1. Verification of rainfall prediction using observation data

No	Station	R-square	R-Skill	RMSE
1	Anjatan	0.77	0.74	65.44
2	Bondan	0.76	0.82	31.23
3	Bugel	0.72	0.73	35.10
4	Cidempet	0.76	0.79	49.55
5	Cikedung	0.77	0.68	43.43
6	Gabuswetan	0.79	0.76	34.55
7	Indramayu	0.80	0.77	50.86
8	Jatibarang	0.74	0.70	46.03
9	Jutinyuat	0.82	0.65	65.11
10	Kedokan Bunder	0.81	0.73	44.60
11	Krangkeng	0.81	0.63	53.56
	Average	**0.78**	**0.73**	**47.22**

The verified rainfall prediction has been built in form of spatial map and converted to .kml format. The contour map was also clipped using blank-grid-node approach when gridding process was performed and entering the boundary map shapefile. The Javascript programming using Google API function could overlay the rainfall prediction maps over Google maps in the web page. Figure 1 shows the example of rainfall prediction in Indramayu district over the Google Maps on the web page. On the right side, there is color bar to identify the rainfall volume in every region of Indramayu, therefore user could estimate the rainfall and also plan for planting. On the left side, there is menu to select the time rainfall want to be viewed on Google maps. On the rainfall prediction maps, there is orange line to separate one village to other villages. By this information map, it is obvious that rainfall variability has pattern even in village scale.

For rainfall prediction view, the library has data of rainfall prediction during 2014 and 2015 (see Figure 1). The data could be input in order to plan rice planting in wet season 2014/2015 and dry season 2015. The wetland map will be base for the rice planting estimation after processing the 3 *dasarian* of rainfall prediction in a village wetland. This procedure follow the result of research mentioning [6]: (1) treshold of rice production in non-irrigation area can be obtained as rainfall of 600 mm or 50 mm/ten days; (2) rice planting can be started in after the backward and forward ten days rainfall reaching 50 mm.

The number of villages in Indramayu that has been collected and written in the web database is 314 villages. Every village has data of rainfall prediction and rice planting information. In a web page, user can see the information detail on rice planting from 2014 to 2015. For more specific information, web page also separated the villages to be 3 sub villages depending on its area. The detail information can be seen by clicking one of the villages or sub villages on the Google maps and subsequently showing information on pop up menu (see Figure 2).

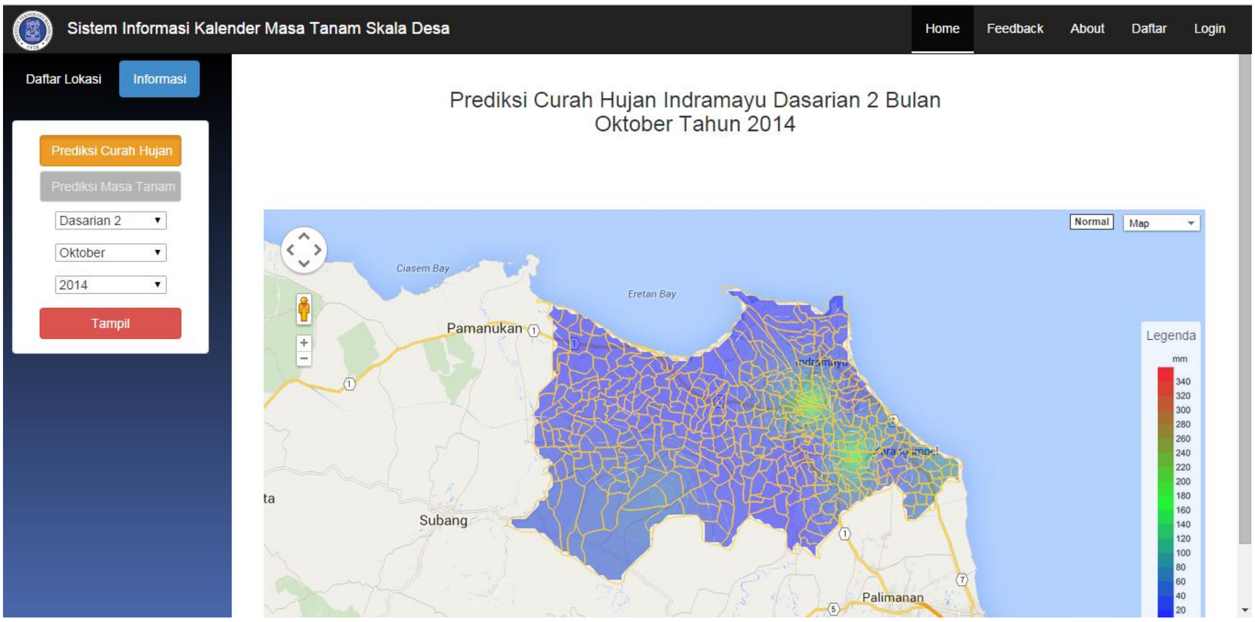

Figure 1. Web page of rainfall prediction in ten-day scale in Indramayu district

Figure 2. Web page of rice planting time in Mekarjaya village of Indramayu district

If user click on *info detail* on the pop up menu, the pdf file will be shown in a new tab of browser to show the more detail information, including village name, planting season, rainfall prediction for 8 next ten-days in every planting season (see Figure 3). Using this information on rainfall prediction for 8 next ten-days, farmers can make strategy on planting activities to get the optimum rice productivity starting from land processing, seeding, rice planting, fertilizing to pesticide distribution.

See Figure 3 for the example of detail information on agricultural planning in Mekarjaya village, Gantar Subdistrict, Indramayu District. In the example, the first season of planting could be started in the 2nd ten-day in January 2015. Below the information of 1st planting season, there is information on rainfall prediction during 8 next ten-day in mm unit. In the 2nd planting season, rice planting could be started in the 2nd ten-day in February 2015. As on the 1st planting season, below the 2nd plantin season also provides information on rainfall prediction during 8 next ten-day in mm unit. Therefore, both in wet season or dry season, farmers can make planning using this full information of rainfall prediction and rice planting season to get their expected productivity.

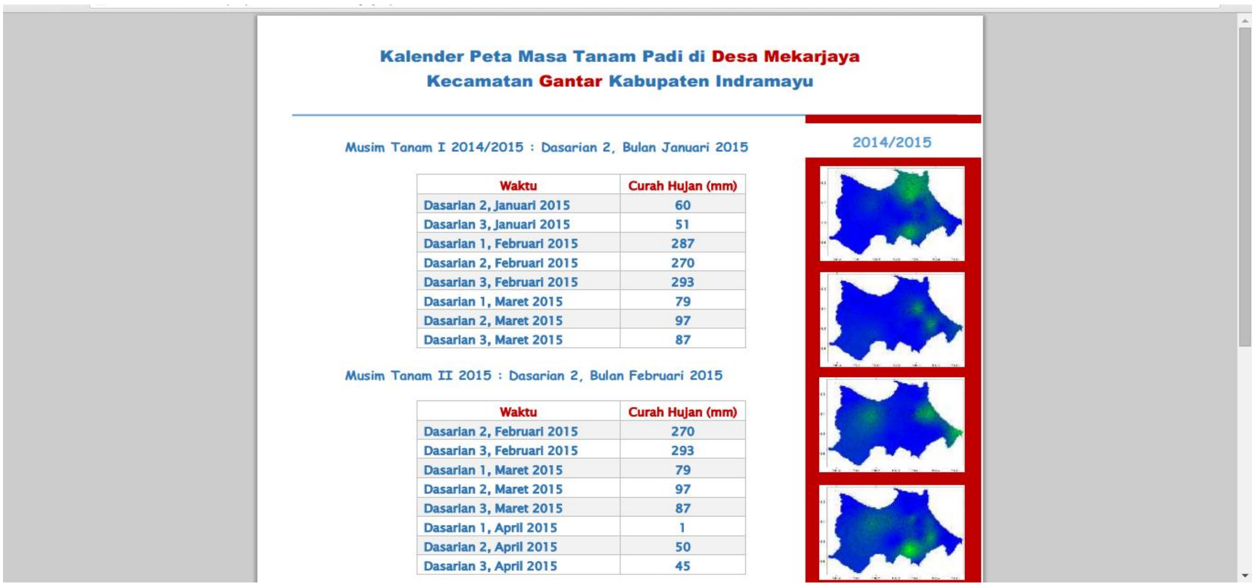

Figure 3. Detail information on planting time prediction in Indramayu in PDF format

In addition to predicted verification, result of rainfall prediction has also been validated. The quick validation was conducted using farmer's observation during October 2014. This data was collected using questionnaire during the workshop to launch this web on information rainfall prediction and planting calendar system. Rainfall observation rainfall was scaled to dry, normal and heavy rain. Based on the collected data, the rainfall are mostly in dry level. This condition has subsequently compared with the predicted result. From 10 data collected, there are 9 data that is accurate (marked by green color) and 1 data that is inaccurate (marked by red color). It means that validation result reached 90% (see Table 2 below).

Tabel 2. Quick validation of rainfall prediction using famer's observation data

No	Village	1st ten-day Oct 2014	2nd ten-day Oct 2014		1st ten-day Oct 2014 (prediction)	2nd ten-day Oct 2014 (prediction)
1	Mundak Jaya	Dry	Dry		7.2	6.4
2	Lohbener	Dry	Dry		49.5	42.9
3	Kiajaran Wetan	Normal	Dry		61.1	35.6
4	Teluk Agung	Dry	Dry		28.8	107.2
5	Plosokerep	Dry	Dry		11.7	9.3

CONCLUSIONS

Information on agriculture is strongly needed by farmers in facing impact of rainfall pattern change. This information is not historical data but the future information that can be used to make planning for the better result than before. The future information should be first verified and validated, so that farmers can get the certainty on water availability for their agriculture activities. In this research, verification shows that result of rainfall prediction is from good to the best with R-square reached 0.78 and R-Skill reached 0.73. In addition, the quick validation even shows that accuracy of rainfall prediction reached 90%. Therefore, this information of rainfall prediction and rice planting is better to be implemented in agricultural planning. If the implementation is success, the economic loss from agriculture in Indramayu can be decrease up to USD 65.436 million per year. Following the modern technology, the information system to deliver prediction results has been done by using Google API for the interface. However, there still need further development to increase the speed of map viewing.

REFERENCES

[1] A. Susandi, A., E. Djamal, I. Las, M. Tamamadin**,** E. Surmaini, *Development of High Resolution Planting Calendar Map to Increase of Rice Productivity in Indramayu*. *Proceedings of The 2nd International Conference On Green World in Business and Technology* (Published by UAS Press, March 2013) Vol. 1, p. E-1

[2] A. Susandi and M. Tamamadin, *Research on Rainfall Pattern Projection in Next 5 years and Adjustment of Planting Pattern in the Dry Land of North Timor Tengah District, East Nusa Tenggara Province* (Research Studies on Agriculture Climate, Cooperation between Institut Teknologi Bandung dan World Neighbors, 2012)

[3] LDL Casas, J. Gatica, F. Jimenez, *Information System for Monitoring and Evaluating Strategies and Policies for Agriculture and Rural Life* (The Ministerial Process and Ministerial Meetings "Agriculture and Rural Life in the Americas", 2007)

[4] D. Farhamsa, A. Susandi, M. Tamamadin, *Climate Change Modelling With Non-Linier Least Square And Fast Fourier Transform Methods* (Proceeding of Internasional International Conference on Mathematics and Natural Sciences, 2008)

[5] J.D. McLean, *A Critical Review of Some Recent Australian Regional Climate Reports* J. Energy and Environment. V. 17 No. 1 (2006)

[6] E. Surmaini, I. Las, *Smart Climate Change Adaptation for Development of Rural Agriculture in Indonesia: Crop Modelling (*Research Report of Institut Teknologi Bandung, Ministry of Agriculture, and Winrock International, 2012)

[7] A. Susandi, E. Djamal, I. Las, M. Tamamadin, E. Surmaini, *Stochastic Climate Model for Implementation in Rice Planting Planning* (Proceedings of the HAGI-IAGI Joint Convention Medan, 2013)