Updated Pranata Mangsa : Recombination of Local Knowledge and Agro Meteorology using Fuzzy Logic for Determining Planting Pattern

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Abstract

This research attempts to evolve the system of new *pranatamangsa* system aimed to produce a prototype, pattern plan simulation, (10 day period) and early comparison of the old and nowadays using combination of *pranatamangsa* system and knowledge of modern agro meteorology. It is hoped that the officials of Agriculture field services in each sub district will get precise guidelines which is scholarly reliable in tutoring farmers in order to enhance their agricultural venture agro meteorology factor. Map server technology is used to make a special-based system. The data presented by using XTJS framework and fuzzy logic. The result of the research can be used first, to analyze new season's deviation compared to the previous one. Second, it can be used to determine planting pattern change, and planting calendar. Finally, it be useful for predicting agricultural commodity that will be cultivated according to the climate condition in one area.

Keywords : *pranatamangsa, fuzzy logic, agro meteorology, planting pattern.*

1. Introduction

According to Daljoeni in Wisnusubroto [8], time arrangement is a local learning created by Ronggowarsito for time approach and has been known by people in Java island for thousand years time arrangement has been equated with Gregorius calendar and used officially by Sri Pakubuwono VII, King of Surakarta in June 2, 1985 [2]. From that moment, *pranatamangsa* had become formal manual in many social and economic activities, especially agricultural activities.pm consists of 12 sections, which each of them has different period (23-43 days) and every transitional period would be marked by a different indicator. Indicator, used for marking up the transitional period, is a natural phenomenon, such as the behavior of trees, animal, weather, and constellation nowadays people in Surakarta who are settled in mount merapi and merbabu with Am (kop pen classification) climate type including Sragen, Karanganyar, Surakarta, Boyolali, Klaten, and Jogja regency, still use this time arrangement knowledge. However, the global warning in this recent 20 years and El nino / la nina phenomenon have made this systems uneffective anymore. As result, there is a rainy / wet season swift in 200-2010, planting time shift and 10 days period determination.

This research attempts to evolve the system of new *pranatamangsa* aimed to produce a prototype, pattern plan simulation, (10 day period) and early comparison of in the old and nowadays using combination of *pranatamangsa* system and knowledge of modern agro meteorology. It is hoped that the officials Agriculture field services in each sub district will get precise guidelines which is scholarly reliable in tutoring farmers in order to enhance their agricultural venture agro meteorology factor. It is the most dominant factor that has a big varied data in determining what will be suitable plant in the tropical area like Indonesia. Map server technology is used to make a special-based system. The data presented by using XTJS framework and fuzzy logic.
Fuzzy logic was firstly introduced by Lotfi A. Zadeh in 1965. The fundamental concept of fuzzy logic is fuzzy set, or in classic math known as crisp [5]. Theoretically, one object / value / component will only have 2 possibility whether if becomes the part of one set or not. Hence, that object will have possibility to be worth 1 if it is formulated as $\mu E[y] = 0$ and 0 is not part of a set formulated with $\mu E[y] = 1$.A fundamental difference between FL and Crisp is in the membership function.

2. Theoretical Backgrounds

There are some traditional weather and climate forecasts such as *Pranatamangsa* in Java, *Kala* in Sunda, *Porhalaan* in Batak, and *Wariga* in Bali. This study focuses more on *pranatamangsa*.

"Pranatamangsa" come from Javanese language. Pranata means procedure and mangsa means season. Mataram Kingdom, Sultan Agung created a Javanese Calendar by changing the calculation system of Saka year which is based on the moon revolution and its movement towards the earth just like the Hijriyah year. However, the year number follows the year number of Saka. He succeeded on integrating the method of Islamic and Javanese (Hindhu) [3].

Javanese calendar contains pranata mangsa. It is closely related to human characters, good day for trading, having

business, wedding, moving house or when they should do a fasting day such as sanger, taliwangke, samparwangke, sarik agung, dhendhan kukudan, etc. *Pranatamangsa* is also used for stating to plant, harvest, and to plant crops.

Pranatamangsa in this study covers season division (mangsa), number of days, farmer activities, the seen characteristics (natural signs) in each of the seasons. The 365 days are divided into twelve seasons or known as "mangsa" in Javanese. Each season is different in its lenght; Kasa (first): 41 days (23 June – 2 August), Karo (Second): 23 days (3 August -26 August), to Sadha (the twelfth): 41 days (14 May-22 June) (third circle) [3].

Those twelve seasons are classified into four general season (first circle) : they are dry season (88 days), labush (first transition : 95 days), rainy (94/95 days), and mareng (second transition: 88 days). Farmer activities for each season rotates anti clockwise (second circle). It starts from first season with planting the crops, second season for plant growth until the twelfth season of harvesting in the rice field. Apart from farmer activities, pranata mangsa also gives the characteristics or natural phenomenon for each season. An example could be seen in the first season (22 June – 2 August), the natural phenomenon is that the wind from the north east to the south west, high temperature, small fountain, falling leaves, grasshopper and insects laying thier egg.

Using pranata mangsa, farmers could plan when they have to start planting and when they are going to harvest. One example is that farmers could start planting paddy in the sixth and seventh seasons which are on November 10 – February 3. In those seasons there will be eind from the west to the east, damp temperature, cold, frequent flood and rain, rambutan and mangsoteen starts to reap especially in the sixt season. In this season birds are diffcult to get their food. Rice harvest could be predicted to take place in the tenth, eleven, and twelfth seasons. The naural phenomena in these seasons are strong and constant wind from the soouth east, little rain, birds starting to build their nest, and hot temperature [3].

3.2 Modern Weather and Climate Forecast

1980s is the starting point of modern weather and climate forecast development especially in Indonesia. This forecast is often represented in forecast model either deterministic or statistic. To make forecast model needs many data and complex analysis which often creates a particular problem. With the computing development, data analysis along with its complicated mathematical calculation is not a problem any longer [3].

For designing and developing climate and weather forecast needs surface data collection such as precipitation, temperature, dampness and pressure. It also needs data from far sensing such as NOAA (National Oceanic Atmosphere Administration) and GMS (Geostationary Meteorology Satellite). Sattelite data could record an area with a wide observation at simultaneously collected in one data scene. Therefore it could be used for observing climate and weather globally. Furthermore, it has high temporal resolution which could be obtained every hour or days. Weather and climate forecast using sattelite data has been developd by LAPAN [3].

Many kinds of modelling technique have been used as well ranging from the simplest one to the most complicated one. Generally, weather forecast modeling uses deterministic approach while season and climate forecast model uses statistic approach. There are several stochastic (statistic) models developed in Indonesia such as time series model (ARIMA, winter-additive, transfer function), Fourier regression, fractal analysis, trend surface analysis, neural network, wavelet transformation, MARS, and regression analisys. Meteorological and Geophysical agency uses probability method, harmonic series and analog method for forecasting the climate in Indonesia [9].

There are some weather and climate changes forecasts adopted to develop in Indonesia. LAPAN has tried to develop a weather and climate forecast model using ITCZ model, anomali sea water surface temperature and General Circulation Models (GCM) CSIRO 9 level (Adiningsih et al, 2000). Nowadays, a model using GCM data which is global has been developed to forecast weather or climate which is local using downscaling technique [4].

3. Methods

Boyolali Central Java becomes the location of this research because time arrangement system was firstly used here. At that moment, Boyolali was part of Kartasura kingdom. It is shown in Fig. 1 how to Boyolali regency is divided in central java province.

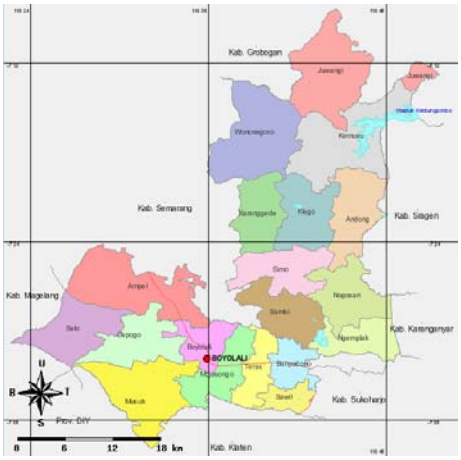

Fig. 1 The division of Boyolali regency, central java province area

This research focuses on 6 sub district in Boyolali regency. They are Andong, Nogosari, Ngemplak, Banyudono, Teras and Sawit. The reason why those six sub district are used as the location of the research are:

1. In social culture point of view, the in habitats in that area apply the pranatamangsa system
2. They represent the area that use technical irrigation for planning grains and no staple food crops (Banyudono, Teras and Sawit)

3. They represent the area that rely on the rainfall in planting their crops (Andong, Nogosari, and Ngemplak)

The data of this research consists of planting pattern data in every sub district, climate data (rainfall, humidity and temperature) in Boyolali area in between 1969-1989 and climate data in 2000-2010. Fuzzy logic system is used for classifying and determining value assurance of major data in every category. Computerized information, using fuzzy logic, are (1) planting pattern visualization, rainfall and the length of time in the new *pranatamangsa* model, (2) planting pattern visualization, rainfall and the length of time in the old *pranatamangsa* model, (3) the comparison of the new and old planting time arrangement, (4) 10 day period table arrangement system architecture can be seen in Fig. 2.

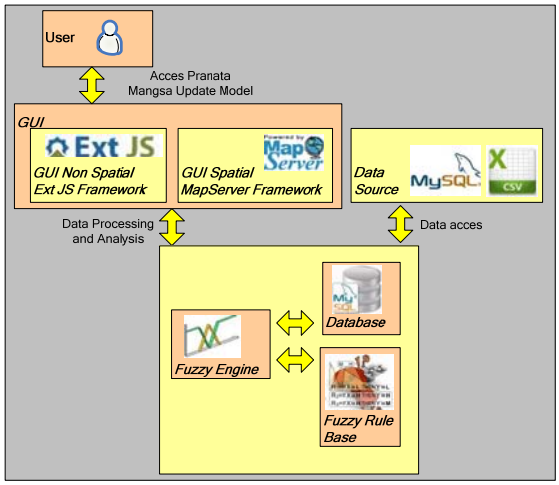

Fig. 2 New *pranatamangsa* architecture system.

In new *pranatamangsa* system, GUI (Graphical User Interface is designed) developed, and oriented toward with regard to both approaches, most of visual processing and data representation were done by framework Ext TJS for non-spatial and map server framework Ext TJS for special. The component, enrolling in the process and analyzes data which is based from basis data MySql. Next, the result of this process will be connected to Rule Base Fuzzy.

Map server is an open source application aimed to show a dynamic spatial map through the internet. It is supported with main feature that has visualization ability and query data raster and vector, in various operation systems (Windows, Linux, Mac Os X, etc). The application of map server technology is based on the consideration that this application can be modified according to the need of the user. Map server is CGI (Common Gateway Interface) application in web server that works when there is a map, legend, scale bar or other references visualization request through URL. Map server provides other visual ability like SVG (Scale bar Vector Graphic), PDF, HTML and various type image file (Fig. 3).

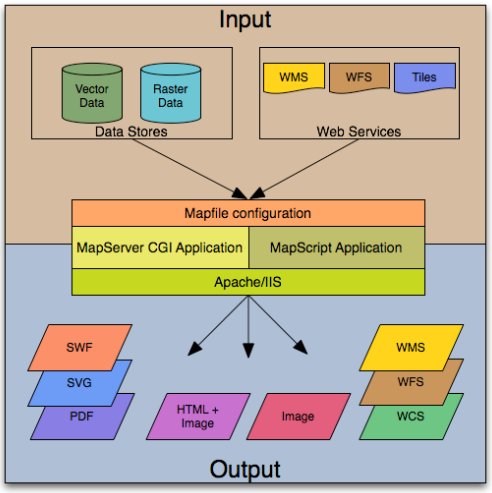

Fig. 3 Basic Architecture of Map Server Application.

4. Findings

Information service provided for the user consists of 5 categories, those are(1) *pranatamangsa* model, (2) comparison of new and old planting time arrangement, 93) 10 day period table, (4) old *pranatamangsa* map,(5) new *pranatamangsa* map. New *pranatamangsa* model provides information about the prediction of time, for location of the research (Fig. 4)

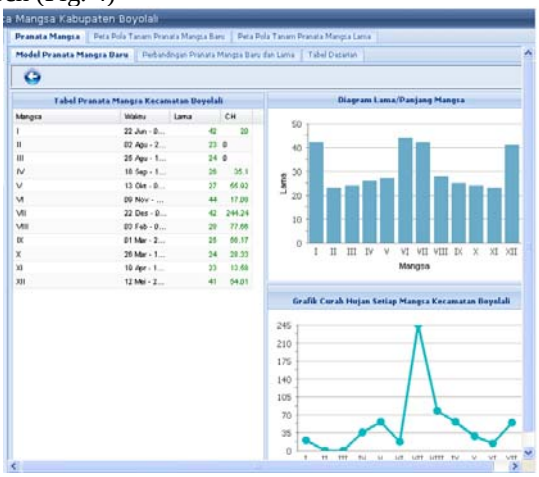

Fig. 4 The page of new planting time arrangement.

The comparison of new and old *pranatamangsa* provides table of the rainfall comparison in 3 decades in the (1969-1979, 1979-1989 and 2001-2010). Other information provided in this table is the graphic of the rainfall comparison in those 3 decades (Fig. 5)

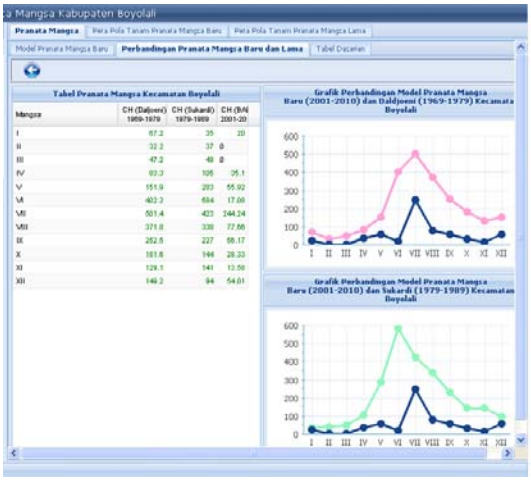

Fig. 5 Graphic and table of rainfall comparison in 3 decades.

10 days period table provides the information about the exact in every period (Fig. 6)

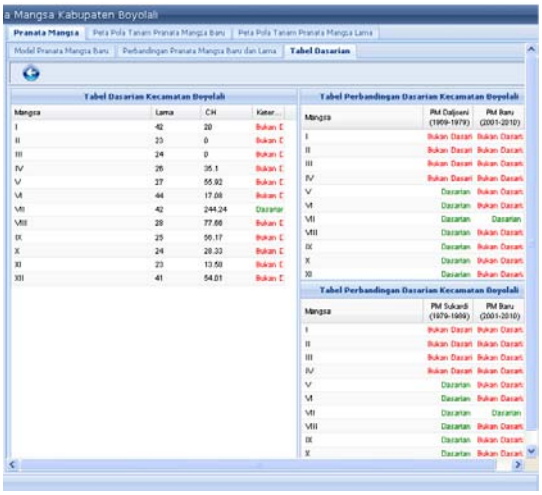

Fig. 6 10 days period table

The map of new and old *pranatamangsa* provides the information of planting pattern swift in every period (Fig. 7). In Agro culture, climate enrolls in the success of cultivating commodity, start from location determination step, cultivation process, area (including Indonesia) in determining plant stability are the temperature and rainfall.Climate data is used for determining agro climatic characteristic

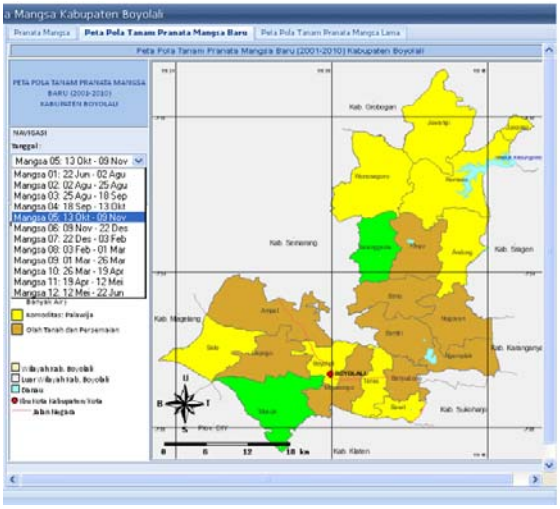

Fig. 7 Planting pattern of new time arrangement map.

Agro climatic Characteristic has important roles in planting physiologic process they are:

a. Temperature (yearly).This factor is related to the planting transpiration process, especially photosynthesis, reparation, and process. Temperature changing has a role forward energy activity or inactivation of the enzyme. Too high temperature will raise the use of photosynthesis energy result. As result, the net production, stored as food reserves in some organ/parts decreases.
b. The high light intensity will raise the vitamin production in the plant like vitamin C, B1 and beta carotene in vegetables and fruits.
c. Humidity (RH) This factor will determine microclimatic condition of the organism to grow such as pest and plant disease.
d. Rainfall in a month and in a year Rain is the important factor for the condition of plant growth. Rainfall influences the level of water reserves needed while the time the distribution of the rain in a year will influence the blossoming and fertilization process. It also determines planting pattern (plants in same season).
e. The amount of wet month (>200mm) and humid month (200-100mm) and dry month (<100mm) according to aldermen criteria. It is related to water reserves/availability especially for grains and no staple food crops.

   According to Agro meteorology-based new *pranatamangsa* model, it will be known about the climatic characteristic in a research area and determined the suitable planting pattern and calendar for the condition of the area.

Climate changing is a natural phenomenon that can happen in global, regional or local level. This affects the changing of planting pattern, planting calendar and the reduction of production. *Pranatamangsa* model, all plied in Boyolali, can be a pioneer in applying planting pattern and calendar. However, nowadays, climate changing is happening significantly and the knowledge of old *pranatamangsa* is less affective because of early season swift.

In the physiology point of view, climate play important roles in the plant's metabolism process so that the growth of the products will be influenced although the rainfall, temperature

and the lighting from the sun are important, the hey factor that determine the success of the agricultural venture is the rainfall. It enables the farmer to fulfill the water reserves.

In order to lessen the risk of planting failure (productivity), planting pattern arrangement is done using new *pranatamangsa* model in 6 sub districts. The result of the analysis and inter pretention of planting pattern calendar presented for farming organization in Teras sub district are:

According to rainfall data in 10 years (2000-2009), Teras had Agro climatic zone c3; that is the area with 5 wet months (rainfall > 200mm) started from December, January, February, March, and April and 5 dry months (<100mm) started from June, July, August, September and October (Oldeman classification) Agro climatic zone C area can be planted with grins twice a year. The planting time is when the rainfall is less than 200 mm per month.It should be done with a good watering management or the use of *gogorancah* paddy system or SRI paddy system (Rice Intensification System)

According to Schinidt Ferguson, Teras area with the rainfall spread in a whole area has medium climate type with 0, 81 for Q index. This medium climate shows that natural vegetation in Teras is the vegetation of hard and forest plant. The rainfall spread based on the *pranatamangsa* model is shown in Fig. 8.

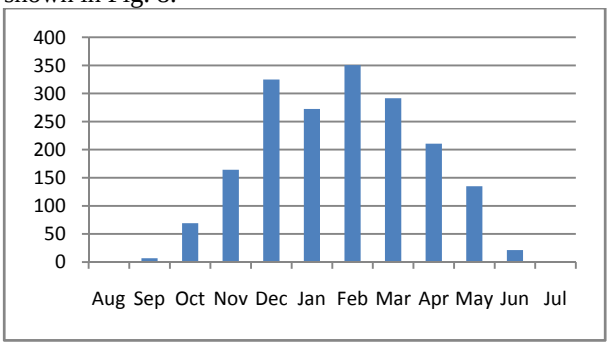

Fig. 8 the spread of rainfall in Teras

According to Isoheyt (yearly rainfall), potential turnover (planting time in a rainy season) will be started if the rainfall is more than 50 mm/10-day period for the next three times. Planting intensity (the rotation of maximum plants, done in a year) according to the new *Pranatamangsa* Model describes the planting pattern in Teras. It is shown by the next table in table 1.

Table 1: The Rainfall Analysis in Determining Planting and Calendar Pattern in Teras

Explain	Month											
	Aug	Sept	Oct	Nov	Des	Jan	Feb	Mar	Apr	Mey	Jun	Jul
Average monthly rainfall	0	7	69	164	325	272	350	292	211	135	21	0
Planting intencity	2											
Yearly Planting pattern	Paddy-paddy-crops/fallow fields											
Food crop												
Occupation farmer	Falllow field		Cultivate the soil & seed	Paddy planting			Cultivate the soil & seed	Paddy planting				Falllow field
Rainfall level				762 mm				637				

Fig. 9 describes monthly rainfall in Teras that has similarity with the old *Pranatamangsa*. At the peak of the rainy season, that are in December, January, February, March and April, the new model of *Pranatamangsa* has less monthly rainfall scale than the old one. Hence, the planting calendar in the new and old *Pranatamangsa* is the same. (see table 2). However, based on the provided rainfall pattern, the area in Teras with reservoir has a little rainfall opportunity so that the farmers will let the reservoir empty.

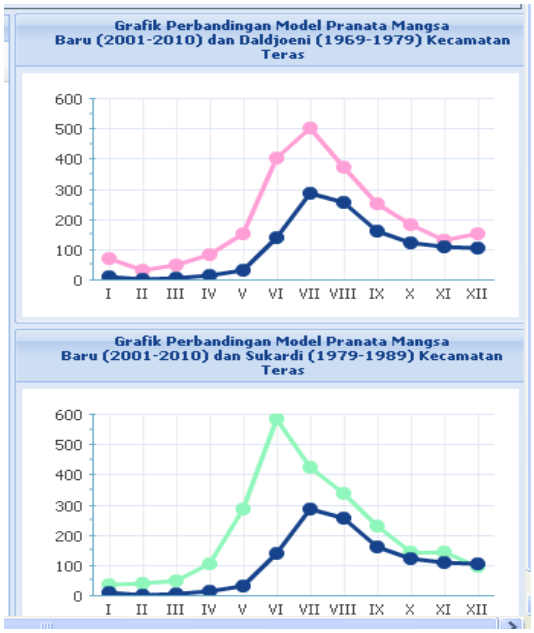

Fig. 9 The Difference between the rainfall pattern of new and old *Pranatamangsa* Model

Crop productivity data in the locations of the research applied the new *Pranatamangsa* Model to determine planting calendar as shown in Table 2.

Table 2: Crop productivity data in the locations of the research applied the new *Pranatamangsa* Model to determine planting calendar

Sub district	Crops in 2010 (kw/ha) Planting Calendar with the old *Pranatamangsa*		Crops in 2011 (kw/ha) Planting Calendar with the new *Pranatamangsa*	
	corn	**Rice plant**	**Corn**	**Rice plant**
Teras	59.47	64.07	*planting*	*planting*
Sawit	58.84	62.10	*planting*	*planting*
Banyudono	68.79	67.86	*planting*	*planting*
Ngemplak	44.62	59.17	*planting*	*planting*
Nogosari	50.13	66.86	*planting*	*planting*
Andong	44.16	58.52	*planting*	*planting*

5. Conclusions

The new model of *Pranatamangsa* is the development of local *Pranatamangsa* knowledge that is combined with the modern agro climatology knowledge. Recombination of local *Pranatamangsa* and Agro climatology knowledge was done by using fuzzy logic method in a data classification process based on the probability concept. The result of this research

can be used to analyze the pattern of season deviation that happens recently compared to the previous season condition. Besides, it can also be used to determine the changing of planting pattern and calendar. Furthermore, the farmer can predict agricultural commodity that is going to be cultivated according to the climate condition in their area.

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