Evaluation of cropping pattern in rainfed areas based on studies of *pranata mangsa* and weather dynamics

M K Zaki¹⁴, N T Furi², Jauhari Syamsiyah³ and Sumani³

¹Agronomy Dept., Graduate School Program, Universitas Sebelas Maret, Ir. Sutami Street Number 36A, Surakarta, Indonesia
²Agrotechnology Dept., Agriculture Faculty, Universitas Sebelas Maret, Ir. Sutami Street Number 36A, Surakarta, Indonesia
³Soil Science Dept., Agriculture Faculty, Universitas Sebelas Maret, Ir. Sutami Street Number 36A, Surakarta, Indonesia
⁴Corresponding author: Email: zakimuhamad30@gmail.com

Abstract. Weather dynamics such as the fifth time of the rainy season and drought are becoming more frequent. These conditions pose a significant impact on the strategies of cultivation such as cropping pattern and crop yields, especially in rainfed areas. One of the steps that can be taken is to return to local wisdom, such as *pranata mangsa*. This study aimed at analyzing the relationship of the variability of precipitation in rainfed areas with *pranata mangsa* and then to evaluate cropping patterns based on the result of the analysis. The study was conducted in rainfed areas of the District of Jumantono, Karanganyar Regency; and District of Teras and District of Ampel, Boyolali Regency in June until December 2014. The research method is a descriptive exploratory survey with purposive sampling based on moderate altitude (200-700 masl). The types of data that are used are primary and secondary. Data analysis was used correlation test. The results showed that precipitation in rainfed areas has a close relationship with *paranata mangsa*. These results explain that *pranata mangsa* still relevant to be used even though it has happened weather dynamics.

1. Introduction

Dynamics weather such as duration of rainy and dry seasons are more frequent. These conditions have a significant impact on cultivation strategies and agricultural production [1], especially rainfed agriculture that directly utilizes rainwater as an irrigation media. The agriculture anticipation and adaptation strategies are needed to keep conscious. Its climate change can be accomplished by shifting the planting period, changing the plants variation, switching the cropping pattern, and shuffling the planting place and location [2]. Cropping pattern judgement using rainfall data needs to be operated in order to adjust an appropriate condition. According to Gomez [3], the cropping pattern needs to suit to rainfall conditions to reduce air deficit in the dry season.

One way to react to the climate change is back to local wisdom in agricultural land managing included in cropping patterns decision. One of them that still operated is *pranata mangsa*. According to Trewartha and Horn [4], information about the *pranata mangsa* is quite necessary for farmers to avoid to choose the planting pattern in the rainfed land.

Cropping pattern that is usually exploited which based on *pranata mangsa* is not considered relevant anymore to the weather dynamics occurrence, therefore it is necessary to conduct a research which related to the cropping pattern evaluation based on *pranata mangsa* and weather dynamics. This
research aims to analyze the relation of rainfall variability with the pranata mangsa application in rainfed agriculture and then evaluate cropping patterns based on the results analysis.

2. Materials and method

2.1. Materials
The research was operated from June to December of 2014 in rainfed agriculture area, medium plain (200-700 masl), Jumantono District, Karanganyar Regency; Teras and Ampel District, Boyolali Regency. Local weather dynamics analysis was supervised by looking at daily patterns of local rainfall, air temperature, and humidity based on descriptive statistical results. Rainfall variability was investigated by employing average data per decade rainfall over the last 30 years (1985-2014). Analysis of local weather dynamics and rainfall variability were accomplished by utilizing Microsoft office excel. Pranata mangsa evaluation was done by practicing correlation test between rainfall area to pranata mangsa using SPSS 16.0 software with $\alpha = 0.05$. The timing and cropping patterns were determined employing the evaluation data of pranata mangsa institutions.

2.2. Method
The research was conducted by the descriptive exploratory method through survey and interview to public figures (PPL, Chairman of Gapoktan) and farmer in farmland. Local weather measurements (air temperature, humidity, and rainfall) were performed by observation method. The data type which employed was primary and secondary. The primary was obtained from local weather observations. Secondary data was earned from various institutions that provide daily rainfall data during the last 20-30 years (1985-2014) such as Jumantono Climatology Station, Territory of Bengawan Solo River Region, and Agricultural Extension Agency of Ampel District.

3. Results and discussions

3.1. Location characteristics
Current site was mostly used as rice field, tegalan, gardens, and settlements. Types of soil in most research sites were Vertisols and Alfisols. Based on Table 1 it can be seen that the average monthly rainfall in Kecamatan Jumantono, Karanganyar District was 187.87 mm/month. Whereas, average monthly rainfall in Kecamatan Teras, Kabupaten Boyolali was 184.07 mm/month. While, average monthly rainfall in Ampel District, Boyolali District was 204.87 mm/month.

Table 1. Rainfall Condition in Jumantono, Teras, and Ampel (1985-2014).

| Lokasi  | Jan  | Feb  | Mar  | Apr  | Mei  | Jun  | Jul  | Agst | Sep  | Oct  | Nov  | Des  | Average |
|--------|------|------|------|------|------|------|------|------|------|------|------|------|---------|
| Jumantono | 317.8 | 366.3 | 304.9 | 231.5 | 108.9 | 70.9 | 55.8 | 13.9 | 25.4 | 120.7 | 268.7 | 315.6 | 187.87 |
| Teras   | 411.4 | 378.6 | 338.7 | 200.9 | 118.3 | 66.4 | 44.4 | 22.3 | 20.7 | 95.4  | 206.9 | 304.8 | 184.07 |
| Ampel   | 500.3 | 409.6 | 344.0 | 234.9 | 120.9 | 126.8 | 48.1 | 21.6 | 28.8 | 106.6 | 202.3 | 314.5 | 204.87 |

Source: Data Analysis

Based on Oldeman climate classification, it can be seen that Jumantono Subdistrict, Karanganyar District, and Teras Subdistrict, Boyolali Regency was entered into type C3 climate while Ampel District, Boyolali Regency was classified into type C2 climate. Type C2 and C3 climates can be implemented on rice cultivation for one growing season and 2 crops for two cropping seasons, with second crop palawija not to fall in dry months [5].
3.2. Dynamics local weather and rainfall variability
Ampel sub-district, Boyolali regency has higher average temperature compared to Jumantono, Karanganyar and Teras sub-districts, Boyolali regency because it is located on higher area. Handoko [6] states that earth’s surface temperatures are lower with increasing latitude as well as temperature decreased by altitude. The vertical spread of the earth surface temperature was an warming origin, therefore the higher the place will be the lower the temperature. District Jumantono, Karanganyar District has high temperatures with low air humidity, yet high rate of rainfall. This shows the dynamics weather due to the circumstances that occurred in District Jumantono contrary to normal situation. Under normal condition, it will be accompanied by high air humidity and low temperatures. Its position was depend on the temperature which determined the air capacity to accommodate moisture and the actual moisture content in place. In wet and hot evaporation areas will be resulting a high density of humidity, while mountainous areas in Indonesia are generally have high humidity because the site temperature is low, therefore the air capacity to hold water vapor is relatively small [6].

![Temperature](image1.png)
![Humidity](image2.png)
![Rainfall](image3.png)

**Figure 1.** The local condition of a) Temperature, b) Humidity, c) Rainfall in July-December 2014.

3.3. Analysis of pranata mangsa between rainfall pattern
*Pranata Mangsa* is a local wisdom to determine the season calculation. Each listed season in the calendar is based on natural events. The *pranata mangsa* farmers utilization by them is now quite
difficult to locate because most of them are considered that the *pranata mangsa* is not relevant to the shifting seasons occurrence. According to Simanjuntak *et al.* [7], the existing *pranata mangsa* system cannot be entirely guided for establishing the growing season initial period due to the climate change, yet the *pranata mangsa* can be evaluated because it is not a rigid pattern.

Table 2. Correlation between *pranata mangsa* and rainfall characteristic.

| Location       | Pearson Correlation | Sig.  |
|----------------|---------------------|-------|
| Jumantono      | 0.874**             | 0.000 |
| Teras          | 0.886**             | 0.000 |
| Ampel          | 0.857**             | 0.000 |

Source: Data Analysis

Based on Table 2, it can be seen that the *pranata mangsa* by occurred rainfall in each study area has close relationship. The *pranata mangsa* assumption order was not relevant to the weather dynamics which was not in accordance with the analysis results. The analysis results of Table 2 explained that the *pranata mangsa* was still relevant and applicable despite weather dynamics and rainfall variability.

*Pranata mangsa* and rainfall region have a direct relationship. *Pranata Mangsa* rainfall pattern needs to be considered in cropping pattern application because it shifting can result in the groundwater availability of which greatly plant growth influences. Types selection and varieties of cultivated crops was also one of the factors that must be considered on *pranata mangsa* calendar.

### 3.4. Crop pattern evaluation

Planting time selection should be precisely performed due to cropping time and pattern were the agricultural production system spearhead. It were established by rainfall conditions. Water and rainfall systems greatly influenced the cropping pattern shape that can be developed [8] Evaluation of planting schedules and patterns at study sites was based on *pranata mangsa* and weather dynamics studies were presented: a) Jumantono District, Karanganyar Regency in the first season (Paddy - Horticulture - Bero), second season (Vegetables - Rice - Palawija - Bero), and third season (Rice - Palawija - Bero); b) Teras Sub-District, Boyolali Regency in the first season (Horticulture - Padi - Palawija - Bero), second season (Paddy - Horticulture - Bero), and third season (Rice - Palawija - Bero); c) Ampel District, Boyolali District in the first season (Vegetables - Rice - Palawija - Bero), second season (Rice - Horticulture - Bero), third season (Rice - Palawija - Bero).

### 4. Conclusions

High rainfall variations which were occurred in rain-fed areas such as District Jumantono, Karanganyar District; Teras and Teras sub-districts, Boyolali district has a close relationship with *pranata mangsa*, therefore *pranata mangsa* is still relevant to be applied despite the weather dynamics such as rainfall variability.

### Acknowledgment

The authors gratefully acknowledged that the present research was supported by Higher Education Science and Technology Development Grant funded by Indonesia Ministry of Research and Higher Education.

### References

[1] Irawan B 2006 *Climate Anomaly Phenomenon (El Nino and La Nina): Long-Term Trend and Its Influence on Food Production* (Bogor: Indonesian Center for Agriculture Socio-Economic and Policy Studies) pp 1-2

[2] Miranda T, Deny H, Ferry Y, Gutomo B A and Ali Y A 2011 *Farmers Adaptation of Climate Change Conditions in Agricultural Management* (Jakarta: Lembaga Ilmu Pengetahuan
Indonesia (LIPI)) pp 3-5
[3] Gomez K A and Gomez A A 1983 Procedure Statistic for Agriculture Research (Philippines: University of Philippines) pp 23-7
[4] Trewartha G T and Horn L H 1995 Introduction to Climatology Fifth Edition (Yogyakarta: UGM Press) pp 17-9
[5] Dwiyono H 2009 Meteorology and Climatology (Malang: Universitas Negeri Malang) pp 31-3
[6] Handoko 1995 Basic of Climatology Second Edition (Jakarta: Dunia Pustaka Jaya) pp 2-6
[7] Simanjuntak B H, Sri Yulianto J P and Krsitoko D H 2010 Preparation of New Model Pranata Mangsa Based on Agrometeorology using LVQ (Learning Vector Quantization) and MAP Alov for Effective Cropping Planning. Completed Year 1 Competitive Grant Report (Salatiga: Universitas Satyawacana) pp 1-7
[8] Sutidjo D 1986 Introduction to Agronomy Production System (Bogor: Bogor Agricultural Institute) pp 3-8