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The Utilization of Enso Information to Evaluate Pranata Mangsa Farming Calendar as an Effort to Climate Change Adaptation

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Abstract : *Food self-sufficiency which is intensified announced by ignoring the climate change phenomenon could be impact on cropping systems and crop yields. 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 ENSO with local weather dynamics and pranata mangsa, then to evaluate the pranata mangsa. The experiment was conducted in June until December 2014 in the Pucangmiliran Village (Tulung District), Karangpandan Village (Karangpandan District) and Pereng Village (Mojogedang District) with descriptive exploratory survey methods. Data analysis was used correlation test. The types of data that are used are primary and secondary data which were obtained through observation and interviews as well as from related institution. ENSO had a small effect on precipitation and pranata mangsa, while precipitation has a close relationship with pranata mangsa, therefore pranata mangsa evaluation is based on precipitation.*

Keywords*: climate change, local weather, precipitation*

I. Introduction

Food self-sufficiency which is intensified announced by the government in the Strategic Plan of the Indonesian Ministry of Agriculture in 2010-2014 (Indonesian Ministry of Agriculture 2013) without considering the dynamics of global climate change can have an impact on cropping systems and crop yields. [1] The agricultural sector is the most threatened, suffering and vulnerable to climate change especially due to water (excess or shortage) stress (BBSDLP 2011). [2] Therefore, one effort to do is return to the local wisdom of the local community, in this case is the pranata mangsa. Pranata mangsa is local wisdom in the Java community to read the signs of nature to determine the calculation of the season which is useful for managing agricultural land (Fidiyani and Ubaidillah 2012). [3]

According to Miranda et al. (2011), farmers adapt to climate change by planting time shifting strategy, change a variety of plants, changing cropping patterns, changing the place and location of planting, it is based on their experience on climate change which took place gradually. [4] According to Simanjuntak et al. (2010), although pranata mangsa is obsolete and not relevant to the current cropping pattern can be evaluated because pranata mangsa was not a rigid pattern. [5]

There are many different ways that can be done to modify the pranata mangsa, one of them is by utilizing new information. ENSO (El Nino Southern Oscillation) is one of the main sources of inter-annual variability season and climate in the world. Based on the results of intensive research it is known that this phenomenon occurs because of the interaction between the ocean and atmosphere (Glantz 2001). [6] The fluctuations of ENSO events in the Pacific Ocean are highly correlated with rainfall in Indonesia (Aldrian et al. 2007). [7] Based on these descriptions, it is necessary to study further how the linkages of ENSO to local weather and pranata mangsa and then evaluate the pranata mangsa related to the utilization of ENSO information.

II. Materials And Methods

The experiment was conducted in June until December 2014 in the Pucangmiliran Village, Tulung District, Klaten Regency (07^{o}35’16.176” SL dan 110^{o}37’29.231” EL with a height of 302 m above sea level), Karangpandan Village, Karangpandan District (07^{o}36’53.359” SL dan 110^{o}04’03.100” EL with a height of 566 m above sea level) and Pereng Village, Mojogedang District (07^{o}32’05.951” SL dan 110^{o}00’23.785” EL with a height of 256 m above sea level) Karanganyar Regency, Central Java, Indonesia. The equipment used in the research is local weather gauges, namely ombrometer (precipitation gauge) and thermo-hygrometer (air temperature and humidity) at each site of the research.

This research is a non-experimental which is the variables approach through the local weather conditions such as precipitation, temperature and humidity. This research used a descriptive exploratory survey method which conducted by observation to analyze its relevance with ENSO and evaluate pranata mangsa system calendar. Determination of the location using purposive sampling with data types such as primary and secondary data.

Analysis of data using correlation analysis at the level of 5% to determine the relationship between precipitation and ENSO, and ten daily precipitation in the area with pranata mangsa that have been in scoring in Table 1, and then evaluate the pranata mangsa timing of planting by comparing qualitative descriptive data.

Table 1. Scoring of criteria in dry, humid and wet months according to Oldeman

Criteria	Explanation	Scoring
Dry	If ten daily precipitation < 33.3 mm	1
Humid	If ten daily precipitation 33.3 mm until 66.7 mm	2
Wet	If ten daily precipitation > 66.7 mm	3

Source: Dewi 2005[8]

III. Results And Disscusion

Precipitation and ENSO Relationship

Climate is an environmental factor that is closely associated with farming conditions. Agriculture is very dependent on the amount of rainfall that available in the agricultural area. The rainfall is one of the elements of climate that most characterizes the climate in Indonesia, because it has a high diversity and volatile in Indonesia. Every region in Indonesia had different precipitation characteristics. Variability of rainfall in Indonesia is affected by the phenomenon in the Pacific Ocean which is the ENSO (Anisa and Sutikno 2015). [9] ENSO value was represented by the Oceanic Niño Index (ONI), which is an index to calculating ENSO value. Precipitation and ENSO relationship for the District of Tulung, Karangpandan and Mojogedang presented in Table 2.

Table 2. Relationship of Precipitation and ENSO

District	Pearson Correlation	p-value
Tulung	-0,384*	0,036
Karangpandan	-0,011	0,952
Mojogedang	-0,253	0,362

Explanation: The number which is followed by an asterisk (*) indicates the relationship at the level of 95%. Table 2 shows that the precipitation and ENSO has a negative relationship (inversely). So if the ONI value is higher then the precipitation will be low and so on. But the correlation value indicates that ENSO has little effect on the results of precipitation in the District Tulung, Karangpandan and Mojogedang. This can be occur because of the existence of other local factors that may be influential such as topography, cloud conditions, wind speed, temperature, humidity and other micro-climatic conditions. The greatest correlation value is in the District of Tulung -0.384 with a p-value of 0.036, then the District of Mojogedang -0.253 with p-value 0.362 and the District of Karangpandan -0.011 with p-value 0.952. Distribution of precipitation in an area within a certain timeframe can increase and decrease. The spread and diversity are influenced by various factors such as geography, topography and air flow (Hilario et al. 2009). [10]

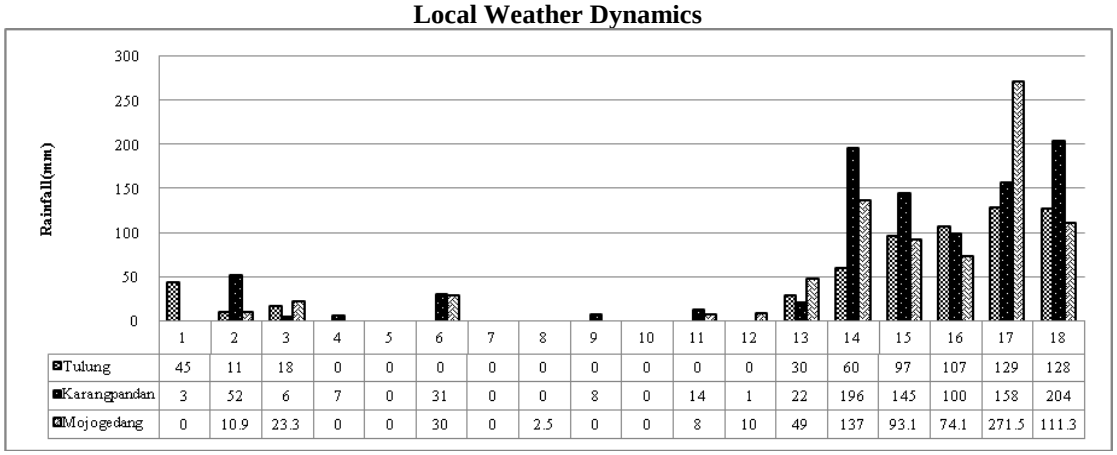
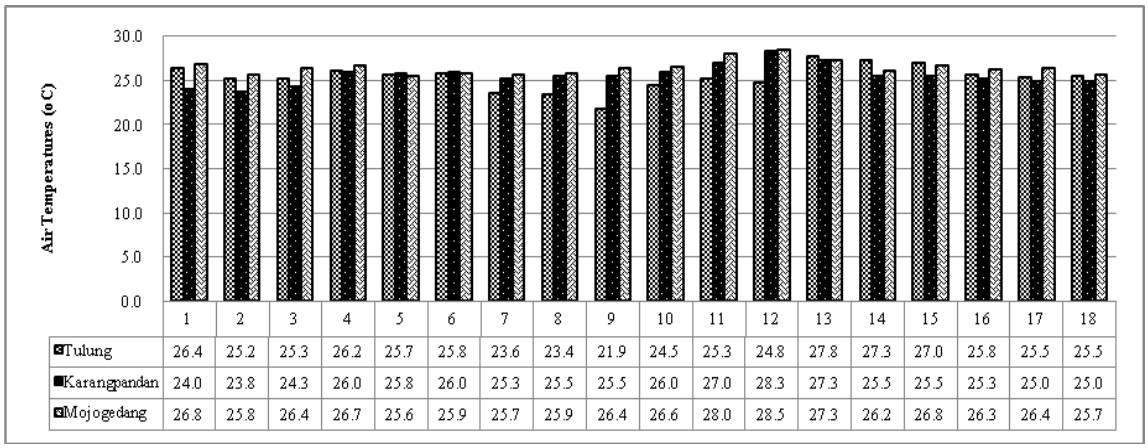


Fig 1. Histogram of ten daily precipitations from Juli to Desember 2014

In Figure 1 we can see that precipitation was very varied. Each region has a different precipitation even within the scope of the same height. The rainfall is the most important element of the climate in Indonesia because of the diversity and fluctuation is very high both in time and altitude. Hilario et al. (2009), states that the admission of precipitation and the time of occurrence can be different from one region to another region due to many factors. [10]

District of Karangpandan has the highest ten daily precipitation intensity of 14 ten daily of rain in 18 ten daily observation, while the District of Mojogedang has 12 ten daily rain and District of Tulung 9 ten daily of rain. Galvan et al. (2013), mentions that on a local scale, topographic characteristics largely determine the variation of precipitation in a region. [11]

Temperature is one of the elements of the climate which has high variability. The temperature can be changed according to the height of an area. The higher of the place, the air temperature would be lower. Ten daily of temperature in each district can be seen in Figure 2.

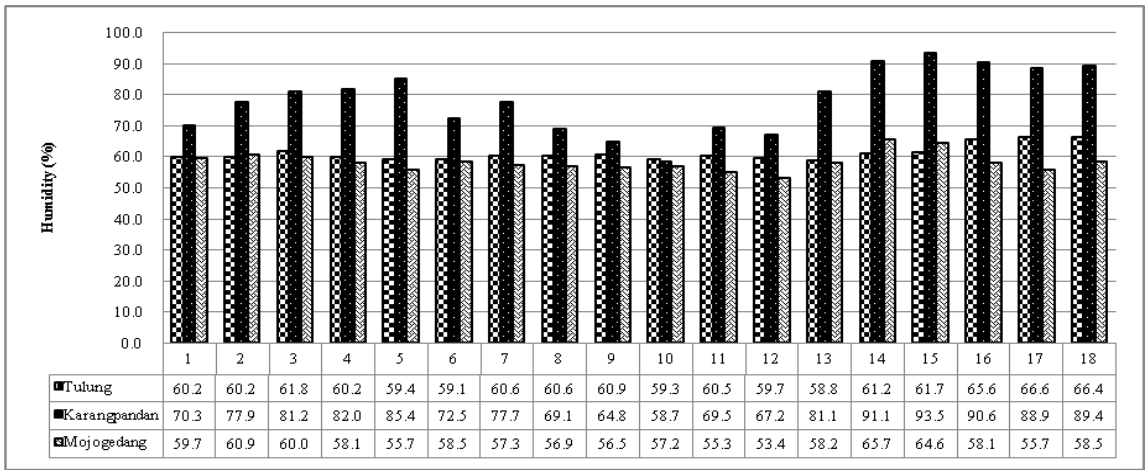


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Tulung	26.4	25.2	25.3	26.2	25.7	25.8	23.6	23.4	21.9	24.5	25.3	24.8	27.8	27.3	27.0	25.8	25.5	25.5
Karangpandan	24.0	23.8	24.3	26.0	25.8	26.0	25.3	25.5	25.5	26.0	27.0	28.3	27.3	25.5	25.5	25.3	25.0	25.0
Mojogedang	26.8	25.8	26.4	26.7	25.6	25.9	25.7	25.9	26.4	26.6	28.0	28.5	27.3	26.2	26.8	26.3	26.4	25.7

Fig 2. Histogram of ten daily air temperatures from Juli to Desember 2014

In Figure 2 the District of Mojogedang which has a highest average temperature. Handoko (1995), states that the temperature at the earth's surface will be lower with the increasing of latitude as well as the decreasing in temperature according to altitude. The difference in the deployment of temperature vertically in the earth's surface is heating source, so that the higher of place, the temperature will be lower. While on the deployment of temperature according to the location of the latitude, the main energy source comes from tropical regions (between 30^{o}LU-30^{o}LS), which is the recipient of the highest solar radiation energy. [12]

Humidity is one of the elements in climate that affect agricultural crops. Therefore besides the precipitation and air temperature, need to consider the humidity of an area to determine an appropriate commodity to be planted. Ten daily of air humidity in each district can be seen in Fig. 3.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Tulung	60.2	60.2	61.8	60.2	59.4	59.1	60.6	60.6	60.9	59.3	60.5	59.7	58.8	61.2	61.7	65.6	66.6	66.4
Karangpandan	70.3	77.9	81.2	82.0	85.4	72.5	77.7	69.1	64.8	58.7	69.5	67.2	81.1	91.1	93.5	90.6	88.9	89.4
Mojogedang	59.7	60.9	60.0	58.1	55.7	58.5	57.3	56.9	56.5	57.2	55.3	53.4	58.2	65.7	64.6	58.1	55.7	58.5

Fig 3. Histogram of ten daily air humidities from Juli to Desember 2014

In figure 3 it can be seen that the District of Karangpandan has a highest ten daily average humidity, then Tulung and Mojogedang. Handoko (1995) states that the humidity at a place depends on the temperature which determines the capacity of air to hold the moisture and the actual moisture content. The actual moisture

content is determined by the availability of water and energy to vaporize it. If the area is wet and hot, then evaporation is huge and the humidity is high. Whereas the mountainous areas in Indonesia generally have high humidity due to low temperature, so that the capacity of air to hold the water vapor is relatively small, [12] Karangpandan was included to mountainous areas that have low temperature so that the air humidity is high.

Evaluation of Pranata Mangsa

The availability of water for plants depends on the presence or absence of water that can be derived from direct precipitation, water sources and availability of irrigation. Therefore, information about cropping patterns will change according to the availability of water. The relationship of precipitation and pranata mangsa can be seen in Table 3.

Table 3. Relationship of precipitation and pranata mangsa

District	Pearson Correlation	p-value
Tulung	0,839**	0,000
Karangpandan	0,781**	0,000
Mojogedang	0,794**	0,000

Explanation: The number which is followed by an asterisk (*) indicates the relationship at the level of 95%.In table 3 it can be seen that District of Tulung has the highest results of Pearson correlation that is 0.839, Mojogedang 0.794, Karangpandan 0.781 and p value 0,000 (less than $\alpha = 0.01$) for each district, which means the relationship between ten daily of precipitation criteria with pranata mangsa on each district is very close. Therefore it can be concluded that precipitation can be used as indicators to evaluate the pranata mangsa. Evaluation of pranata mangsa farming calendar is done by descriptive analysis. In this research, ENSO shown to have a low impact on the formation of local climate in Indonesia, especially in District of Tulung, Karangpandan and Mojogedang due to the larger influence from the local weather such as rainfall, temperature and humidity.

On the calendar system of pranata mangsa in mid-October to early May (mangsa kalima to mangsa desta) is the rice planting season, mid-May to mid-September is the time of planting second crops (mangsa sadha to mangsa katiga) and the end of September to mid-October (mangsa kapat) is a period of break. According to Dewi (2005), the water needs of paddy including its percolations approaching to 200 mm, while for second crops to be deprived of water if rainfall is less than 100 mm per month. Therefore for the paddy field in ten daily of rainfall needed greater than 66.7 mm and for the second crops between 33.3 mm to 66.7 mm of rainfall. [8] The evaluation of pranata mangsa planting time calendar are presented in tables 4, 5 and 6.

Table 4. Evaluation of pranata mangsa planting time calendar in the District of Tulung

MONTHS	January			February			March			April			May			June			July			August			September			October			November			December		
DAILY TENTH	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
PRANATA MANGSA PLANTING PATTERN	Paddy												Second Crops												Break			Paddy								
SECONDARY DATA: TEN DAILY OF RAINFALL	101	115	112	105	98.8	87.4	74.4	65.2	70.5	75	69.9	29.2	41	34.4	38.3	23	14	11.3	8.5	17.9	11.1	5	2.9	4.3	2.5	5.5	11.3	18.4	21.1	39.5	59.2	63.4	68	57.9	80	114
PRIMARY DATA: TEN DAILY OF TEMPERATURE (°C)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26.4	25.2	25.3	26.2	25.7	25.8	23.6	23.4	21.9	24.5	25.3	24.8	27.8	27.3	27	25.8	26	25.5
PRIMARY DATA: TEN DAILY OF MAX TEMPERATURE (°C)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	26	26	28.3	27	27	25.3	25.3	23.5	26	26	26	28.8	27.8	28	26.5	26	25.5
PRIMARY DATA: TEN DAILY OF HUMIDITY (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60.2	60.2	61.8	60.2	59.4	59.1	60.6	60.6	60.9	59.3	60.5	59.7	58.8	61.2	62	65.6	67	66.4
EVALUATION OF PRANATA MANGSA (SUITABLE/NOT SUITABLE)	√	√	√	√	√	√	√	x	√	√	√	x	x	√	√	x	x	x	x	x	x	x	x	x	x	x	√	√	x	x	x	√	x	√	√
ALTERNATIVE OF PLANTING PATTERN I	Paddy						Maize									Break														Kale/Spinach			Paddy				
ALTERNATIVE OF PLANTING PATTERN II	Paddy						Cucumber/Eggplant						Kale/Spinach			Break														Kale/Spinach			Paddy				

Recommendations

1) Alternative of Planting Pattern I

a) Paddy was planted on late November to early March (1 time planting season).

b) Maize can be planted in mid-March to early June, but must be noted for irrigation.

c) Mid-June to mid-October is a period of break, because there is no water. Farmers can plant the short-lived vegetables horticultural crops such as kale or spinach in their yards.

d) The short-lived vegetables horticultural crops such as kale or spinach can be planted in late October to mid-November.

2) Alternative of Planting Pattern II

a) Paddy was planted on late November to early March (1 time planting season).
b) Cucumber or eggplant can be planted in mid-March to early May and kale or spinach on mid-May to early June, otherwise it can also planting the other short-lived vegetables horticultural crops.
c) Mid-June to mid-October is a period of break, because there is no water. Farmers can plant the short-lived vegetables horticultural crops such as kale or spinach in their yards.
d) The short-lived vegetables horticultural crops such as kale or spinach can be planted in late October to mid-November.

Tabel 5. Evaluation of pranata mangsa planting time calendar in the District of Karangpandan

MONTHS	January			February			March			April			May			June			July			August			September			October			November			December		
DAILY TENTH	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
PRANATA MANGSA PLANTING PATTERN	Paddy												Second Crops												Break			Paddy								
SECONDARY DATA: TEN DAILY OF RAINFALL	145	131	166	158	161	130	140	133	122	141	107	79.5	61.9	42.7	48.8	47	19	23.2	13.3	14.8	16.9	2.4	1.6	14.4	8	14.3	17.7	21.7	36.8	89.4	105	111	115	128	126	171
PRIMARY DATA: TEN DAILY OF TEMPERATURE (°C)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22.7	22.4	23.7	25	24.3	24.3	24.6	24.8	24.8	24.9	26	27	26.3	24.5	24	24.3	23	24
PRIMARY DATA: TEN DAILY OF MAX TEMPERATURE (°C)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24	23.8	24.3	26	25.8	26	25.3	25.5	25.5	26	27	28.3	27.3	25.5	26	25.3	25	25
PRIMARY DATA: TEN DAILY OF HUMIDITY (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	70.3	77.9	81.2	82	85.4	72.5	77.7	69.1	64.8	58.7	69.5	67.2	81.1	91.1	94	90.6	89	89.4
EVALUATION OF PRANATA MANGSA (SUITABLE/NOT SUITABLE)	√	√	√	√	√	√	√	√	√	√	√	√	x	x	√	√	x	x	x	x	x	x	x	x	x	x	√	√	x	√	√	√	√	√	√
ALTERNATIVE OF PLANTING PATTERN I	Paddy												Lettuce/Kale			Break														Paddy							
ALTERNATIVE OF PLANTING PATTERN II	Paddy												Cucumber			Break														Paddy							

Recommendations:

1) Alternative of Planting Pattern I
a) Paddy was planted on late October to late April (2 times planting season).
b) Lettuce or kale can be planted on early May to early June, otherwise it can also planting the other short-lived vegetables horticultural crops.
c) Mid-June to mid-OctoberPertengahan Juni Mid-June to mid-October is a period of break, because there is no water. Farmers can plant the short-lived vegetables horticultural crops such as lettuce, kale or spinach in their yards.
2) Alternative of Planting Pattern II
a) Paddy was planted on late October to late April (2 times planting season).
b) Cucumbers or the other short-lived vegetable horticultural crops can be planted on early May to late June, but must be noted for irrigation.
c) Early July to mid-October is a period of break, because there is no water. Farmers can plant the short-lived vegetables horticultural crops such as kale or spinach in their yards.

Tabel 6. Evaluation of pranata mangsa planting time calendar in District of Mojogedang

MONTHS	January			February			March			April			May			June			July			August			September			October			November			December		
DAILY TENTH	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
PRANATA MANGSA PLANTING PATTERN	Paddy												Second Crops												Break			Paddy								
SECONDARY DATA: TEN DAILY OF RAINFALL	173	140	226	183	159	159.4	184	131	133	127	115	91.2	90.8	60.5	46.4	29	28	29.1	19.1	27.5	12.3	3.1	16.7	19.4	8	21.7	18.7	24.5	30.3	101	143	130	93	109	157	220
PRIMARY DATA: TEN DAILY OF TEMPERATURE (°C)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26.8	25.8	26.4	26.7	25.6	25.9	25.7	25.9	26.4	26.6	28	28.5	27.3	26.2	27	26.3	26	25.7
PRIMARY DATA: TEN DAILY OF MAX TEMPERATURE (°C)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28.8	28.3	28.3	29.8	28	27.3	28	27	27.5	27.5	28	31.3	29.5	27.5	28	27.3	28	28.3
PRIMARY DATA: TEN DAILY OF HUMIDITY (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	59.7	60.9	60	58.1	55.7	58.5	57.3	56.9	56.5	57.2	55.3	53.4	58.2	65.7	65	58.1	56	58.5
EVALUATION OF PRANATA MANGSA (SUITABLE/NOT SUITABLE)	√	√	√	√	√	√	√	√	√	√	√	√	√	x	√	x	x	x	x	x	x	x	x	x	x	x	√	√	√	√	√	√	√	√	√
ALTERNATIVE OF PLANTING PATTERN I	Paddy												Kale/Spinach			Break														Paddy							
ALTERNATIVE OF PLANTING PATTERN II	Paddy												Maize									Break								Paddy							

Recommendations:

1) Alternative of Planting Pattern I

a) Paddy was planted on late October to early May (2 times planting season).
b) Kale or spinach can be planted on mid-May to late June, but must be noted for irrigation, otherwise it can also planting the other short-lived vegetables horticultural crops.
c) Early July to mid-October is a period of break, because there is no water. Farmers can plant the short-lived vegetables horticultural crops such as kale or spinach in their yards.

2) Alternative of Planting Pattern II

a) Paddy was planted on late October to late April (2 times of planting season).
b) Maize can be planted on early May to late July, but must be noted for irrigation.
c) Early August to mid-October is a period of break, because there is no water. Farmers can plant the short-lived vegetables horticultural crops such as kale or spinach in their yards.

Explanations:


: Paddy period


:ond crops period


: Break period due to the absence of water


: Horticultural plant period

Based on the results of the comparison on pranata mangsa cropping pattern system calendar with local precipitation conditions there are things that are not appropriate, namely the growing season with the water availability based on the average of rainfall in each research area. Therefore, evaluation of the pranata mangsa farming system calendar was nedded. This is in accordance with the opinion of Suntoro (2008) cit. Sarwanto et al. (2010) which states that the science of pranata mangsa is currently used by a minority of the Java community, especially farmers and poets associated with the livehoods shifting of some people to other sectors which are not related to agriculture and extreme seasonal changes make the pranata mangsa which is a guideline for farmers in Central Java since long ago seemed no longer valid so that necessary to be corrected. [13]

IV. Conclusion

Conclusion

ENSO has a small effect on rainfall, so that ENSO can not be used to evaluate the pranata mangsa.

The ENSO indicators can not be used to evaluate the pranata mangsa, so rainfall is used to evaluate the pranata mangsa. Evaluation of the pranata mangsa time of planting calendar are as follows:

a. The District of Tulung

1) Alternative of Planting Pattern I: Paddy – Maize – Break – Short-lived vegetable horticultural crops (Kale/Spinach)
2) Alternative of Planting Pattern II: Paddy – Short-lived vegetable horticultural crops (Cucumbers/ Eggplant) - Kale/Spinach – Break – Kale/ Spinach

b. The District of Karangpandan

1) Alternative of Planting Pattern I: Paddy – Paddy – Short-lived vegetable horticultural crops (Lettuce/Kale) – Break
2) Alternative of Planting Pattern II: Paddy – Paddy – Short-lived vegetable horticultural crops (Cucumbers) – Break

c. The District of Mojogedang

1) Alternative of Planting Pattern I: Paddy – Paddy – Short-lived vegetable horticultural crops (Kale/Spinach) – Break
2) Alternative of Planting Pattern II: Paddy – Paddy – Maize – Break.

V. Sugesstion

It is necessary to analysis of the factors that influence the rainfall beside the ENSO's, in addition to the results of the pranata mangsa evaluation in the form of several alternative cropping patterns can be tested and then used as guidelines to avoid losses due to climate change.

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