Identifying the Influence of El Nino on Rainfall Characteristics in the Inland and Swamp Irrigation Areas in Lampung Province

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Abstract:

El Nino events cause a reduction in rainfall in most parts of Indonesia. The precipitation reduction varies depending on the intensity of El Nino and geographic location areas concerned. Reduction of rainfall in Indonesia could potentially disrupt the operational of irrigation in some areas in Indonesia. As a result of El Nino events, there has been a decrease in the average food production in Indonesia during the years 1968 to 2000. This study aims to analyze the influence of El Nino on rainfall characteristics in Sekampung Irrigation Area and Rawa Sragi Irrigation Area in Lampung Province. Sekampung Irrigation Area and Rawa Sragi Irrigation Area are inland irrigation area and swamp irrigation area, respectively. Rainfall data from Pringsewu Rainfall Station (for Sekampung Irrigation Area) and Palas Rainfall Station (for Rawa Sragi Irrigation Area) have been used to investigate the impact of El Nino on the potential reduction in the irrigation water availability in both irrigation areas. The results show that due to the influence of El Nino, there has been decline on rainfall in the dry season in the area observed. The month of August, September, and October are the most sensitive months to the effects of El Nino. The results also showed that there is no fact indicates whether inland irrigation areas are more sensitive to El Nino impact rather than swamp irrigation areas and vice versain Lampung Province. Based on the classification of climate patterns in Indonesia, the whole area in Lampung province is included in areas where rainfall is strongly influenced by the monsoon circulation. Based on this fact, we can conclude that there is no different impact of El Nino on Way Sekampung and Rawa Sragi irrigation area.

Keywords: El Nino, Rainfall Characteristics, Inland and Swamp Irrigation Areas, Lampung Province

1. INTRODUCTION

Lampung is one of the provinces that support the national rice production of Indonesia. Currently, in the Lampung Province, there are about 219,000 hectares of irrigated rice fields (Ministry of Public Works, 2005). The paddy fields are mostly (about 163,000 ha) located in the irrigation areas spreading across two large basins, Way Sekampung Basin and Way Seputih Basin (Nippon Koei, 2002). Largest irrigated area in Lampung Province is Way Sekampung Irrigation Area. Irrigation water for this area is supplied by Argoguruh Weir built in 1935. The weir serves about 66,000 ha of paddy fields. In the upstream areas of Way Sekampung Basin there is a multi-purpose dam which is Batutegi Dam. One of the tasks of this dam is to supply water to Argoguruh Weir in order to meet the needs of irrigation water in the dry season. In the rainy season Argoguruh Weir rely on the baseflow of the midstream region of Way Sekampung Basin. In addition to Way Sekampung Irrigation Area, there are three other important irrigation areas in the basin of Way Seputih – Way Sekampung. They are Way Seputih Irrigation Area, Way Pengubuan Irrigation Area, and Rawa Sragi Irrigation Area. These irrigation areas are inland irrigation areas except Rawa Sragi Irrigation Area. The area is located in the Eastern coast downstream of Way Sekampung. The area was developed in the scheme of drainage and land reclamation project implemented during the year 1978 to 1991. Rawa Sragi Irrigation Area consists of total potential paddy field of 23,000 ha. Of this number, 21,000 ha have become functional areas.

2. PROBLEM IDENTIFICATION

In the dry season, usually the availability of irrigation water is reduced. This resulted in declining agricultural productivity. The reduced of irrigation water availability can also be caused by the reduction in the average annual discharge due to the influence of natural phenomena such as El Nino. El Nino is part of the El Nino Southern Oscillation (ENSO). ENSO itself is a phenomenon consisting of two oceanic phases. El Nino represents warm phase and La Nina represent cold phase. They are connected through a fluctuation in atmospheric pressure over the South Pacific called the Southern Oscillation (Shrestha and Kostaschuk, 2005). El Nino event is usually followed by La Nina event with return period of the event is 3 – 7 years (Garcia *et al,* 2003). The events is caused by the abnormally high surface temperature of the Pacific Ocean on the west coast of Ecuador and Peru. This temperature abnormality resulted in major world-wide consequences such as flood in regions such as coastal Peru and Ecuador as well as drought conditions in regions like Indonesia, New Guinea, and Australia (Cane, 2005).

El Nino impact in Indonesia usually is the rising of sea surface temperature followed by a low volume of clouds that trigger less rainfall and prolonged periods of drought. This circumstance hits the agricultural sector in Indonesia. The impact of El Nino in Indonesia contributes to the average decline in national food production during the years 1968-2000. The decline was approximately 1.79 million tons, or about 3.06% of all food production (Irawan, 2006). Several studies suggested that El Nino have resulted dramatic environmental degradation in several watersheds in Indonesia, particularly in Java Island. This condition will be followed by other watersheds in various regions in Indonesia. Research on the minimum and maximum discharge data from 52 rivers spreading all over Indonesia shows a decrease in the minimum discharge that leads to the problem of drought in the observed watershed. This suggests that the watershed in Indonesia has experienced significant degradation due to climate change caused by El Nino. El Nino event of year 1997 was recorded as the most extreme El Nino. As the results of the event, 517.614 ha of paddy fields in Java Island have no crops due to the scarcity of water (Ministry of Agriculture, 2010). Other previous research investigating the effect of ENSO in Indonesia have been undertaken by some hydrologist in Java dan Sumatera Island (Nicholls, 1981 and 1984a; Ropelewski and Halpert, 1987; Konnen *et al.*, 1998; Haylock and McBride, 2001; Hamada *et al.,* 2002). The most recent study was undertaken in order to investigate the impact of El Nino to precipitation characteristics in the area of Mega Rice Project of Central Kalimantan (Susilo *et al.,* 2013). Most of the research concluded that the inter-annual variability of monthly rainfall in Indonesia is strongly related to ENSO. The last research in Central Kalimantan demonstrated that the impact of El Nino on the rainfall of the area observed increased periodically.

The precipitation reduction varies depending on the intensity of El Nino and geographic location areas concerned. Reduction of rainfall in Indonesia could potentially disrupt the operational of irrigation in some areas in Indonesia. This study aims to analyze the influence of El Nino on rainfall characteristics in Sekampung Irrigation Area and Rawa Sragi Irrigation Area in Lampung Province. Sekampung Irrigation Area and Rawa Sragi Irrigation Area are inland irrigation area and swamp irrigation area, respectively. Rainfall data from Pringsewu

Rainfall Station (for Sekampung Irrigation Area) and Palas Rainfall Station (for Rawasragi Irrigation Area) have been used to investigate the impact of El Nino on the reduction in precipitation and irrigation water availability in both irrigation areas. The location of the study is illustrated in Figure 1.

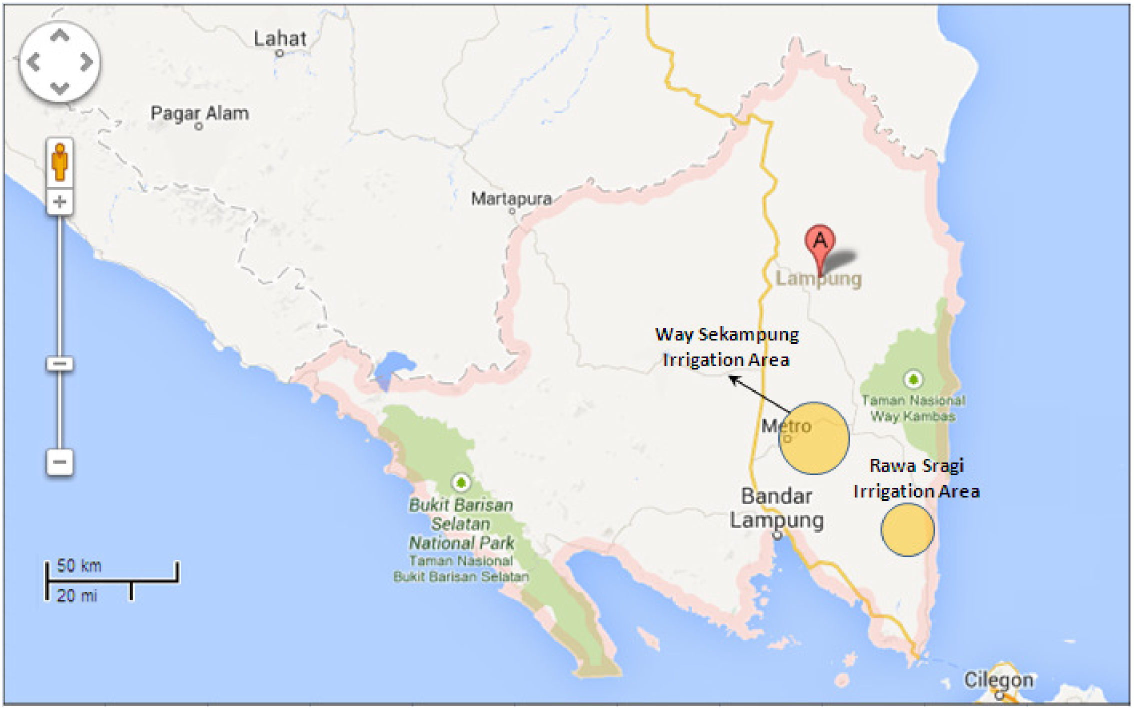

Figure 1. The location of Way Sekampung Irrigation Area and Rawa Sragi Irrigation Area

3. ENSO DETECTION

There are some methods can be used to find out the years of ENSO events. One of the methods is using the Southern Oscillation Index method (SOI) to identify the strength and phase of ENSO in the observed area. The SOI is a standardized index of southern oscillation and calculated based on the observed sea level pressure differences between Tahiti of South America and Darwin of Australia. The SOI describes the phenomenon that affects large-scale atmospheric and oceanographic features of the tropical Pacific Ocean (NOAA, 2014; Adiku and Stone 1995). Negative SOI represents El Niño phase and positive SOI represents La Niña phase, respectively (Mabaso *et al.* 2009). The SOI can be calculated using expression as follows (Australian Bureau of Meteorology 2002):

$$SOI = \frac{10(P_{diff} - P_{diffav})}{SD(P_{diff})} \quad (1)$$

where:

P_{diff} = (average Tahiti MSLP for the month) - (average Darwin MSLP for the month)

P_{diffav} = long term average of P_{diff} for the particular month

$SD(P_{diff})$ = long term standard deviation of P_{diff} for the particular month.

The value of SOI is monthly SOI. In this study, the calculation of SOI is not directly undertaken. It is because calculated SOI has been given by Australian Bureau of Meteorology in its website.

The correlation between SOI and monthly rainfall is investigated in this study in order to predict the effect of ENSO on the hydrological condition in the area of study. The correlation coefficients in this study are calculated using Pearson's correlation method. Based on Rodgers and Nicewander (1988), this method is one of the most popular methods for calculating correlation between two groups of data. Pearson's correlation method is expressed as:

$$r_{xy,j} = \frac{\sum_{i\min}^{i\max}(x_{i,j} - \bar{x}_j)(y_{i,j} - \bar{y}_j)}{(n-1)s_{x,j}s_{y,j}} \tag{2}$$

where:

$r_{xy,j}$	=	correlation coefficient between monthly rainfall and SOI for month *j*
$x_{i,j}$	=	monthly rainfall of month *j* for year *i*
$\bar{x}_j$	=	average monthly rainfall of month *j* for
$y_{i,j}$	=	SOI of month *j* for year *i*
$\bar{y}_j$	=	average SOI of month *j* over whole years of data
$S_{x,j}$	=	standard deviation in rainfall for month *j* over whole years of data
$S_{y,j}$	=	standard deviation in SOI whole years of data
n	=	number of data years
i_{min}	=	initial year
i_{max}	=	final year

The classification of r value is given as follows:

- $r < 0.3$ refers to weak correlation value
- $0.3 < r < 0.7$ refers to moderate correlation value
- $r > 0.7$ refers to strong correlation value

4. RESULTS AND DISCUSSIONS

Figure 2 describes the relationship between SOI and monthly rainfall in dry season. The correlation coefficients calculated using Pearson's correlation method is given in Table 1. The table and the graph indicate that the month of August, September, and October are the sensitive month to the impact of El Nino in Pringsewu station. The month of August and September have moderate sensitivity with Pearson's correlation value of 0.37 and 0.32, respectively. The month of October has strong sensitivity with Pearson's correlation value of 0.84. On the other hand, the month of September and October are the sensitive month to the impact of El Nino in Palas station. Pearson's correlation value for both months are 0.47 and 0.79, respectively.

Table 1. The correlation coefficients (r) calculated using Pearson's correlation method

Month	r for Pringsewu	r for Palas
June	0.19	-0.01
July	0.29	0.20
August	0.37	0.20
September	0.32	0.40
October	0.84	0.79

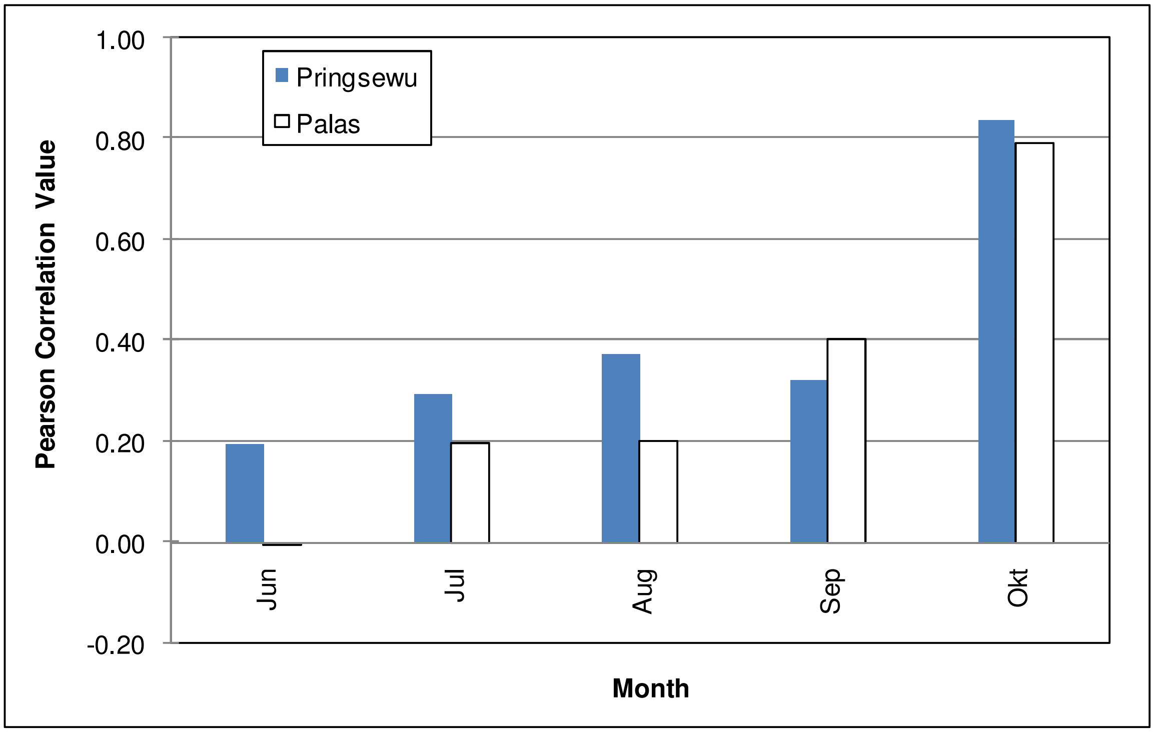

Figure 2. Graph of correlation coefficients (r) calculated using Pearson's correlation method

Figure 3 illustrates the monthly average of dry season (Jun – Oct) rainfall from Pringsewu Rainfall Station (for Sekampung Irrigation Area) and Palas Rainfall Station (for Rawa Sragi Irrigation Area) for 1986 – 2000 data. The dry season average monthly rainfall for both Pringsewu and Palas stations are 80.7 mm and 88.7 mm, respectively. In Pringsewu Station, there are 8 years of wet year and 7 years of dry year. On the other hand, in Palas Station there are 9 years of wet year and 6 years of dry year. Wet year refers to the year which the dry season monthly rainfall is larger than the one for whole data years. Oppositely, dry year refers to the year which the dry season monthly rainfall is less than the one for whole data years. The graph also shows that dry year average monthly rainfall for both stations associated to the events of El Nino in Indonesia. Between year 1986 and 2000 there are several El Nino events in Indonesia. The El Nino happened at year of 1987, 1991, 1994, and 1997. In these years, the dry season monthly average rainfall of both stations is significantly dropped into low value. The value of dry season monthly average rainfall of both stations in El Nino years is presented in Table 2 below:

Table 2. The value of dry season monthly average rainfall for Pringsewu and Palas Station in the El Nino years

Year	Pringsewu (mm)	Palas (mm)
1987	52.7	48.5
1991	13.1	33.6
1994	22.2	5.1
1997	9.2	24.4

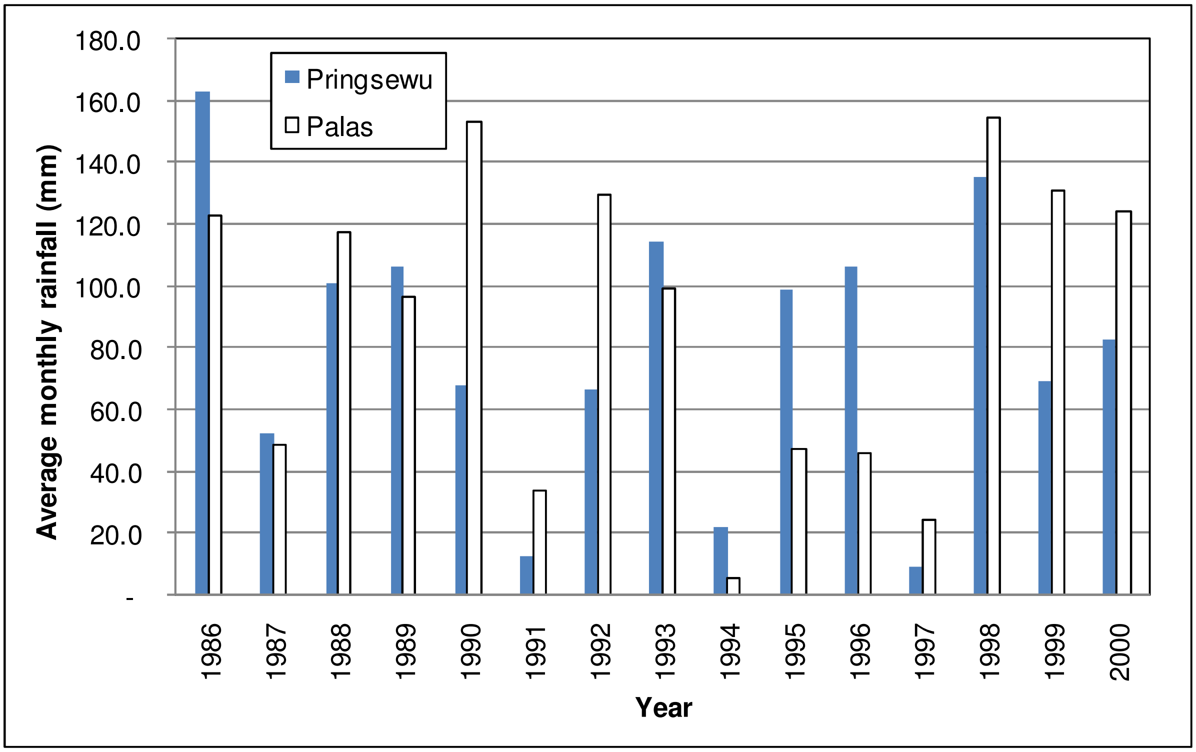

Figure 3. Monthly average of dry season (Jun – Oct) rainfall from Pringsewu Rainfall Station and Palas Rainfall Station for 1986 – 2000 data.

From the tables and graphs above it is obvious that rainfall from Pringsewu Station has more sensitive months to El Nino impact rather than the one from Palas Station. However, there is no pattern can be identified in order to differentiate the sensitivity of each irrigation areas towards El Nino impact. It is also difficult to say whether inland irrigation areas are more sensitive to El Nino impact rather than swamp irrigation areas and vice versa. The analysis only shows that the availability of irrigation water in Way Sekampung Irrigation Area and Rawa Sragi Irrigation Area are significantly affected by the impact of El Nino. If we refer to some previous studies, the effect of climate anomalies on rainfall magnitude is highly depending on position of the area to the equatorial monsoonal influence, type of topography, land use, hydrological systems and some other factors (As-Syakur, 2010). Aldrian and Susanto (2003) have determined the classification of climate patterns in Indonesia. In these classifications, the whole area in Lampung province is included in areas where rainfall is strongly influenced by the monsoon circulation. Monsoon is a seasonal wind caused by the effect of variation in heating and air pressures between land and surrounding sea. When we refer to the similarity of climate patterns, we can conclude that there is no difference impact of El Nino on Way Sekampung and Rawa Sragi irrigation area.

5. CONCLUSIONS

The analysis in this study results in some conclusions as follows:

1. The month of October is the sensitive month to the impact of El Nino in Way Sekampung and Rawa Sragi Irrigation Area.
2. Average monthly rainfall in the dry year for Pringsewu and Palas rainfall stations associated to the events of El Nino in Indonesia.
3. In the year of El Nino 1987, 1991, 1994, and 1997, the dry season monthly average rainfall of both stations is significantly dropped into low value.
4. There is no fact indicates whether inland irrigation areas are more sensitive to El Nino impact rather than swamp irrigation areas and vice versa.
5. Based on climate patterns, there is no different impact of El Nino on Way Sekampung and Rawa Sragi irrigation area.

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