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Exposure of dryland Farming to the ENSO Phenomenon in Kebumen District

T I Utami, T Handayani, Kuswantoro  
1Department of Geography, Faculty Mathematics and Natural Science, University of Indonesia  
trindahutami@gmail.com

Abstract. The impact of the ENSO phenomenon causes a shift in the pattern of rainy and dry season. This will affect the agricultural activities Kebumen regency, crop failure and decreased productivity are few of the results of such impacts. This study aims to find the exposure pattern of dryland agriculture in Kebumen regency towards ENSO phenomenon and its association with maize productivity. The Data used is the daily rainfall period of 1986-2016 from 32 observer rain stations. There are five parameters to identify exposures are early deviation and duration of a dry season, rainfall of the maize, the maize harvest, the number of rainy days in maize harvest and the method used is scoring and overlay. The pattern of high exposure to dryland agriculture tends to be in mountainous areas. The El Nino Period of 2015 does not result in dryland agriculture significantly being exposed due to low exposure, while the La Nina period results in moderate to high exposure because land does not require too much water. In the El Nino period of 2015, maize productivity tends to rise 43% from normal conditions. In the La Nina period in 2010, the productivity of maize dropped by 63% compared to normal conditions.

Keywords: El Nino, ENSO phenomenon, Exposure, La Nina, Dryland.

1. Introduction

The geographical position of Indonesia is located in the tropics, between Asia and Australia, between the Pacific Ocean and the Indian Ocean, as well as passed the equator, consists of the island and archipelago stretching from west to east, there are many straits and bays, causing parts of Indonesia prone to the phenomenon of changes in weather /climate. Indonesia climatic conditions affected the ENSO phenomenon that comes from the eastern region of Indonesia (Central Pacific Equator / Nino 3.4).

El Nino is a global phenomenon of ocean-atmosphere interaction system that is characterized by the warming of sea surface temperatures in the equatorial Eastern Pacific (Nino 3.4) or sea surface temperature anomalies in the area of positive (hotter than the average). La Nina is the opposite of El Nino events ie reduction in sea surface temperature in the equatorial region of the Pacific Ocean from its normal temperature [1], the El Nino and La Nina are both associated with the Southern Oscillation, therefore this phenomenon is known as ENSO. El Nino's impact in Indonesia depends on the condition of Indonesian territorial waters. El Nino will reduce the amount of rainfall in Indonesia when the seawater temperature is relatively cold. However, if the temperature of seawater in Indonesia is relatively warm, El Nino does not affect the rainfall in Indonesia. Meanwhile, La Nina will tend to cause heavier rainfall than the normal condition in Indonesia.

Climate variability associated with El Nino events and La Nina has a significant impact on agricultural land. The natural phenomenon El Nino causes droughts and drought in agriculture, while
La Nina could increase rainfall and extend the length of harvest season and can lead to crop failure. ENSO events are often accompanied by a prolonged drought due to the decrease in the amount of rainfall, including Java. The agricultural sector is very vulnerable to climatic aberrations due to indicate a shift in the rainy season or drought and changes in rainfall patterns that affects the shifting of planting and harvesting of food commodities [2]. The agricultural sector in Kebumen regency is one of the main driving sectors of the regional economy because it is a staple food buffer in Central Java. Kebumen district has 65,632 ha of dry land agriculture area (49.4%), which means having a sizeable area [3]. Kebumen is also a producer of various such as maize. The average productivity of maize in Kebumen 2015 72.33 Ku / ha increased significantly when compared to 2014 which reached 68.90 Ku / ha. However, the productivity of maize in Kebumen can be decreased due to a shift in the pattern of the rainy season and dry season (4%), which means having a sizeable area [3].

ENSO phenomenon provides a significant impact in Kebumen, Central Java, mainly in a shift of the pattern between the rainy season and dry season. It affects the agricultural activities in the district of Kebumen, including crop failure, reduced productivity and changing planting time. Exposure to dry land farming will occur along with the ENSO phenomenon in Kebumen. Therefore the research needs to be done as to the benefits of this research can anticipate the impact of the ENSO phenomenon will result in the loss of agricultural land Kebumen. This study has two research questions are:

1. What is the pattern of dryland farming exposure to the ENSO phenomenon in Kebumen?
2. What is the impact on the productivity of maize towards the ENSO phenomenon in Kebumen?

2. Methods
2.1. Study Area
Kebumen Regency is one of 35 districts/municipalities in the province of Central Java. Administratively Kebumen is divided into 26 districts, 449 villages and 11 urban villages with conditions some areas are coastal and hilly areas, while most of the lowland [3]. The total area of Kebumen amounted to 133,749 hectares, or by 1,337,49 km². Kebumen Regency of Wonosobo and Banjarnegara regency in the north, Purworejo in the east, Banyumas and Cilacap districts in the west and is adjacent to the Indian Ocean in the south (figure 1).

Figure 1. Study Area in Kebumen District
2.2. Materials
The secondary data required in this study include daily rainfall data for 30 years in the period 1986 to 2016 from the Department of Natural Resources and Energy and Mineral Kebumen. DEM data from the USGS used to create a map of altitude and slope, land use data and administration of BIG in 2015, ONI index of the web http://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php maize production data from the CPP and the Department of Agriculture Kebumen.

2.3. Data Processing
The method used in this research is to process tabular data and statistics data, as well as the processing of spatial data. Tabular data processing is to determine the deviation at the beginning of the dry season, the duration of the dry season, the average intensity of precipitation planting, the harvest rainfall and number of rainy days in the period as El Nino deviate 2015 and La Nina in 2010 using standard deviation formula in each 32 rainfall stations.

\[ S = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}} \]

where \( S \) = Standard Deviation, \( x_i \) = sample data, \( \bar{x} \) = average, \( n \) = amount of data

Determining the class value of the deviation of the five parameters, by calculating the number of classes (k) determined by \( k = 1 + (3.3) \log n \), where \( n \) is the number of rainfall stations. Determine the fifth class interval parameter. To get the class interval (I) on the values of the parameters of exposure, using this formula \( I = \frac{R}{k} \). The value of R is the difference between the largest data value and the smallest data value, while k is the number of classes that have been predetermined. The five parameters are the deviation of the beginning of the dry season, the duration of the dry season, the rainfall of the planting season, the rainfall during the harvest period, and the number of days of rain during the harvest, then each overlayed to become a map of the level of exposure to the ENSO phenomenon, which is stated in the following formula (Level of Exposure = P1+P2+P3+P4+P5). Scoring results are divided into three classes, namely low, moderate, and high exposure (table 1).

Table 1. Exposure Scoring Levels to the El Nino and La Nina Period

| Interval La Nina | Level of Exposure | Score | Interval El Nino |
|------------------|-------------------|-------|------------------|
| < 7              | Low               | 1     | <2               |
| 8 s.d 15         | Moderate          | 2     | 3 s.d 5          |
| > 16             | High              | 3     | >5               |

Source: Data Processing, 2018

Spatial data processing are mapping the area of irregularities with Thiessen polygon method using software Arc.GIS 10.1, and mapmaking exposure area and intersect with overlay techniques using software Arc.GIS 10.1.

2.4. Analyze Data
In a study on the patterns of exposure to dry agricultural land to the ENSO phenomenon which aims to answer the problem of how exposure pattern affects the dry agricultural land to the ENSO phenomenon in the district of Kebumen using spatial analysis to see the formation of the exposure pattern within the research area resulting from the parameters of climate change based on the level exposure regions.
To answer the second question, how the ENSO phenomenon to agricultural activities by using comparative analysis between exposure maps of agricultural land to the ENSO phenomenon with land productivity values described by chart or table to determine the relationship. ENSO phenomenon considered as a factor, while the result of the productivity of maize is considered as a result of factors.

3. Results and Discussion
3.1. Deviations Rainfall and Drought
Deviations seasons and rainfall is a parameter that can be measured to see climate change as El Nino and La Nina. ENSO phenomenon (El Nino Southern Oscillation) can affect the variability of annual rainfall. Total rainfall may be higher when the La Nina, and can be lower when the El Nino. Climate change caused by the ENSO phenomenon will lead to changes in annual climate patterns such as the late start of the rainy season and dry season. The years of the occurrence of El Nino, La Nina, and abnormal conditions can be seen in figure 2 below.

![Figure 2. Occurrence Graphic of El Nino year, La Nina and Normal Condition.](image)

Source : Data Processing, 2018

By looking at the chart above, a strong El Nino happened in 1997 with the ONI index of more than +2, El Nino moderate and weak in the years 2003, 2005, 2009, and in 2015 El Nino tends to be moderate to strong. A strong La Nina years, namely in 1973, 1988 and 1999. La Nina happened in 2007 and 2010. In the occurrence of La Nina which is in 2010 resulted in higher average annual precipitation in Kebumen. In the occurrence of El Nino, namely 1997, 2002 and 2015, the average annual rainfall tends to be low. This proves that the impact of the ENSO phenomenon on rainfall in Kebumen. The intensity of the rain tends to rise or lower than the average normal conditions could result in an impact on several agricultural crops.

Deviations of the season happened in 2010 that in La Nina phenomenon happened and in 2015 when El Nino in comparison with the normal conditions in the years 1986-2016. This is evidenced by the existence of irregularities early dry season when the La Nina is back 3 dasarian of normal conditions. Deviations duration of the dry season happens more quickly with reduced duration of as much as 13 dasarian the period of La Nina and going on longer with increasing 1 dasarian on the El Nino period of normal conditions (table 2).
Table 2. Deviations of Dry Season In the period of El Nino, La Nina and Normal Condition

| Information         | Year                  | Irregularities in El Nino | Irregularities in La Nina |
|---------------------|-----------------------|---------------------------|---------------------------|
|                     | On average (1986 - 2016) | 2015 (El Nino) | 2010 (La Nina) |
| Early Drought       | Dasarian May 3rd      | Dasarian May 3rd         | Dasarian June 2nd        | No irregularities | Backward 3 dasarian |
| Duration Drought    | 16 dasarian           | 17 dasarian              | 3 dasarian               | I grew dasarian   | Reduced 13 dasarian |

3.2 Cultivation of Maize in Kebumen

Maize farmers in Kebumen usually use dry agricultural land or paddy fields and carry out a rotation of seasonal crops planted with rice. Types of maize that grown in Kebumen majority is hybrids maize, due to a high price for corn farmers. Maize plant growth is strongly influenced by one of the climatic factors, that is rainfall. Increase or decrease in production of corn is determined also by the intensity of the rainfall. The corn crop is cultivated in the dry season or when the climate is relatively dry because these plants tend not to require a lot of water. Based on interviews with farmers corn, it can be concluded that the time is used for planting to harvest (table 3).

Table 3. The Pattern of Corn Planting in Kebumen

| Corn Cultivation time | Jan | Feb | March | April | May | June | July | Agt | Oct | Nov | Dec |
|-----------------------|-----|-----|-------|-------|-----|------|------|-----|-----|-----|-----|
| Planting season       |     |     |       |       |     |      |      |     |     |     |     |
| The harvest           |     |     |       |       |     |      |      |     |     |     |     |

3.3 Exposure Levels Against Regional ENSO phenomenon

Climatic deviation caused by the ENSO phenomenon causes aberrations and irregularities season rainfall intensity. Changes in precipitation can be used as an indicator to determine the value and grade five parameters. To obtain the final value of exposure to the ENSO phenomenon, by using the scoring method for the fifth parameter, namely the deviation of early dry season, the duration of the dry season, rainfall during the planting season, rainfall during harvest and rainy days of harvest. Deviations early dry season, duration of the dry season and rainy days of the harvest maize do not deviate significantly when the El Nino period. El Nino 2015 and La Nina 2010 phenomenon do not have too much significant effect on the third parameters.

Deviation of rainfall in the growing season of maize during the 2015 El Nino does not deviate significantly if compared to the period of La Nina in 2010. This is because maize is a plant that did not require water at planting time, if the excess water in the growing season it can cause some damage, including bulih growth on maize stalks that will affect the quality of maize. Deviation of rainfall during the growing period of La Nina 2010 was dominated by a class 2 aberrant deviation 69-137 mm dominate in the region ramps up rather steep. Grade 6 aberrant deviation >343 mm, which is potentially damaging maize crops in the area are steep in the period of La Nina in 2010. Distribution of classes of rainfall deviations during El Nino and La Nina maize planting periods can be seen in figure 3 and 4.

Deviations of rainfall in the harvest of maize in the period of El Nino is not the irregularities. This is because at the time of the maize harvest does not need water, dry conditions are needed in maize. Dry conditions needed to dry the maize kernels and maize stalks are then able to generate income for maize farmers. Deviations average rainfall the harvest of maize in the period of La Nina in 2010 had a very significant impact in Kebumen. This is proven by the deviation of rainfall in the highest class is class 6
deviated >130mm dominate (figure 4). In the event of a La Nina 2010, maize crops failed and provide impacts to the farmers because the produced cannot be sold to the collectors.

3.4 Exposure Pattern of Dryland Agriculture to the ENSO phenomenon

Pattern exposure of dryland farming on the ENSO phenomenon in Kebumen obtained from combining variable deviation early dry season, the duration of the dry season, precipitation growing season, rainfall harvest, and rainy day harvest has classified the value of exposure to long fetches using the scoring method to map farmland, Mapmaking exposure processed by methods intersect with ArcGIS 10.1 software. Agricultural land belonging to the dry land agriculture in Kebumen include rainfed areas, moor, dry forest, mixed farms, and fields / huma. Dryland farming are mostly located in the northern district and a small portion is located in the coastal Kebumen. Dryland agriculture, in general, produce commodity crops, fruits, vegetables, and forest products. The spatial pattern of dryland farming exposure to the weather phenomenon El Nino and La Nina can be seen in figure 7 and 8.
Farming dry land exposed by El Nino in 2015 was dominated by exposure to low levels. This is evidenced by the low exposed area has the greatest general 85% of the total area of agricultural land is dry and dominated by a mix of garden land. Dryland agriculture in the period of La Nina in 2010 was dominated by a moderate level of exposure. 67% of dryland farming area has a moderate exposure that dominates in the garden mix.

3.5 Exposure Dryland Agriculture Linkages Against ENSO phenomenon With Maize Productivity

According to interviews with farmers indicated that the presence of the La Nina phenomenon in maize production can be decreased drastically due to high rainfall in the growing season led to crop failure. However, at the time of occurrence of El Nino in 2015, maize production does not decline, but even tends to rise due to the decreasing of rainfall in the growing season. This can be evidenced by the average productivity of maize in figure 9.

On dryland farming exposure exposed to low, productivity gains in the period 2015 El Nino tends to be higher than normal and La Nina. The productivity of maize in coastal areas tend to have high productivity, as in the district Ambal, Mirit, Puring, Petanahan, Klirong. This is because the rainfall received is less than the maize plants that grow in mountainous areas so that productivity in coastal regions tend to be higher. The highest productivity in Sub Petanahan with El Nino conditions are low at 8.10 tonnes / ha and the lowest is exposed District of La Nina Buluspesantren low at 2.11 tonnes / ha (figure 10).

Exposures exposed dry land farming El Nino was only one sub-districts and 13 sub Pejagoan La Nina being exposed. In this moderate exposure, the productivity of maize decreased compared with the productivity of maize exposed La Nina is low. The productivity of the largest and smallest are in Sub Pejagoan, with the largest exposure was that El Nino 6.67 tons/ha while the smallest with La Nina was namely exposure of 1.22 tonnes/ha (figure 11).
Exposures dryland farming Heavily exposed only 2 sub-districts and sub-district Karangsambung Karanggayam. High exposure in the period of La Nina causes corn productivity is only 1.80 tonnes/ha compared to the normal time is 4.63 ton/ha and in the period of El Nino is 6.13 t/ha (figure 12). The corn crop is exposed to high located in the district and sub-district Karangsambung Karanggayam which is a mountainous area and has a harvested area is not too broad because corn can not grow well than in coastal areas.

Figure 10. Productivity of Maize with Low Exposed of ENSO Phenomenon

Figure 11. Productivity of Maize with Moderate Exposed of ENSO Phenomenon

Figure 12. Productivity of Maize with High Exposed of ENSO Phenomenon
4. Conclusion
Exposure patterns exposed dry land farming tends to be high in the mountains. El Nino period in 2015 did not result in dryland farming significantly exposed as predominantly low exposure, while La Nina period resulted in moderate to high exposure because of dryland farming does not need much water. Exposure of dryland agriculture in Kebumen is dominated by low exposure to the El Nino period that dominates in the garden mix, higher exposure in the period of El Nino is in the northern part of the district which is dominated by dryland agriculture fields and forest types. In the period of La Nina dominated by the exposure being distributed in the central part to the northern districts with altitude region 50-500 meters above sea level and dominates in dryland farming types mixed farms. Low exposure in the period of La Nina distributed in parts of the coastline is dominated by rainfed and high-exposure is in the northeastern part of the district that dominates in the garden mix.

El Nino and La Nina have an impact on the productivity of the maize crop in Kebumen. In the period 2015 El Nino, maize productivity tends to rise 43% from normal condition. In the period of La Nina in 2010 significantly lower maize productivity is decreased 63% from normal condition. Maize productivity declined in La Nina conditions in 2010 caused by presence shift in the early dry season, reduced the duration of the dry season, the average rainfall planting and harvests maize deviate above the normal range, and the number of rainy days the harvest of maize distorted.

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