IMPACTS OF RAINFALL, TEMPERATURE AND RECENT EL NIÑOS ON FISHERIES AND AGRICULTURAL PRODUCTS IN THE WEST COAST OF SABAH [2000 – 2010]

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ABSTRACT. *The impacts of El Niño Southern Oscillation (ENSO) phenomenon on rainfall and temperature as well as the relationships between rainfall, temperature and ENSO phenomenon on fish landings and production of palm oil Fresh Fruit Bunch (FFB) along the West Coast of Sabah during the last 10 years have been examined. Rainfall, temperature, Southern Oscillation Index (SOI) values, fish landings and production of FFB from available local departments have been studied and analyzed for the past 10 years. On the whole, there is significant positive correlation between rainfall and temperature on fish landings. The correlation coefficient between rainfall and fish landings is +0.74 with fish landings leading by 2 months. Also, fish landings and temperature are directly correlated with correlation coefficient of +0.83 with no time lag. However, a negative correlation between SOI values on fish landings is observed whereby 1 month before fish landings increase, the SOI values become low or negative. Analysis of production of palm oil on the same meteorological parameters show that there is significant positive correlation between rainfall on production of FFB, monthly temperature on production of FFB and SOI values on production of FFB for the 6-year study period. When rainfall is considered, the production of FFB is correlated with rainfall at +0.83 with rainfall leading by 3 months. The correlation coefficients between temperature and production of FFB is +0.87 with temperature leading by 4 months. Also, when SOI values are considered, production of FFB leads SOI by 3 months with the correlation coefficient of +0.62. Fish landings along the West Coast of Sabah are enhanced during El Niño periods while production of palm oil FFB is favoured during La Niña periods although floods are not desirable. By understanding the ENSO phenomenon and the subsequent changes in rainfall and temperature, preparations are most needed in order to sustain and promote the fisheries and agricultural products for sustainable development in the economy of Sabah.*

KEYWORDS.ENSO, fish landings, FFB, rainfall, temperature

INTRODUCTION

Malaysia is known to have hot and humid weather throughout the year as it is located close to the equator. This condition is applicable to Sabah. Northeast and Southwest Monsoons are two monsoon regimes found to dominate the weather and influence the activities in Sabah. According to Cooke (2003), Sabah or specifically the capital city, Kota Kinabalu receives more precipitation during the Southwest Monsoon and less precipitation during the Northeast Monsoon. This condition is reversed if compared to Peninsular Malaysia where more rainfall is fed during the Northeast Monsoon and less rainfall during the Southwest Monsoon.

Generally, climate in Sabah is mostly predictable. However, there is a more frequent and rampant abnormal variation known as the El Niño Southern Oscillation (ENSO) phenomenon is inducing weather variability in Sabah. El Niño is defined as the sustained warming of the ocean temperature accompanied by a decrease in the strength of the Pacific Trade Winds results in a reduction of rainfall over the eastern and northern of Australia as well as the surrounding areas. This brings serious implications on all economic sectors, including fishery and agriculture sectors that have been the main economy sources of the locals and non locals living in Sabah.

The main objectives of this study are to observe the influence of rainfall and temperature in respect of ENSO phenomenon on fish landings and the palm oil production in the West Coast of Sabah for the past decade. It is important because both fisheries and palm oil production are the major sources of economy supporting the livelihood of people. Moreover, by understanding the impacts of ENSO on rainfall and temperature, further precautions as well as technological improvements can be taken in order to sustain and enhance the production from these sectors whenever El Niño takes place in the future.

MATERIALS AND METHODS

In this study, statistical data (fish landing data, palm oil production data, meteorological data and monthly Southern Oscillation Index (SOI) were collected from various governmental departments: Fishery Department of Sabah, Malaysian Palm Oil Board (MPOB), the Meteorology Department of Sabah and Bureau of Meteorology, Australia for the study period of year 2000 to 2009.

Fish landing data (metric tonnes) along the West Coast of Sabah, specifically in Kota Kinabalu that was obtained from the Fishery Department of Sabah were in monthly based for the last 10-year period. The data has been obtained either directly from the owners of fish companies of the study area or local market survey by Fishery Department of Sabah. An estimated error of about 10 % has been drawn due to the frequency of recording data by the appointed assistant as well the fluctuations in the market requirements (Jaafar-Sidik*et al*.,2010).

The palm oil production data for the West Coast Division of Sabah as well as the Kudat Division that comprise Kota Belud, Penampang, Papar, Kota Marudu and Kudat were included in the study. These official data was collected from the Malaysian Palm Oil Board (MPOB) where the production of the fresh fruit bunches of palm oil is available.

Meteorological data used in this study including records of monthly rainfall amount (mm) and records of 24-hour mean temperature (°C) from 2000 to 2009 were provided by the Meteorological Department of Sabah particularly for station in Kota Kinabalu.

Monthly Southern Oscillation Index (SOI) values during the last 10-year period were downloaded from the Bureau of Meteorology, Australia in order to identify the El Niño episodes occurred during the study period. The SOI values provide a simple measure of the strength and phase of ENSO (El NiñoSouthern Oscillation) phenomena by its monthly mean air pressure difference between Tahiti and Darwin. SOI reflects the changes in atmospheric circulation patterns and can fluctuate from month to month. Sustained negative values over a period of several months can be observed when an El Niño is developing in the Pacific (BOM, 2010).

All data were grouped and analyzed for analysis purposes. Furthermore, statistical analysis involving correlation analysis between fish landings with meteorological variables and production of palm oil with meteorological variables were applied to further enhance the analysis.

RESULTS AND DISCUSSION

Effects of El Niño Events on Rainfall and Temperature

El Niño Southern Oscillation (ENSO) phenomenon is a middle term climate change that may alter the pattern of rainfall and temperature of the affected area. ENSO is typically indicated by Southern Oscillation Index (SOI) whereby sustained negative SOI values indicate the occurrence of warm phase (El Niño) while positive SOI values indicate the presence of cold phase (La Niña). Figure 1 shows the SOI values throughout the 10-year study period.

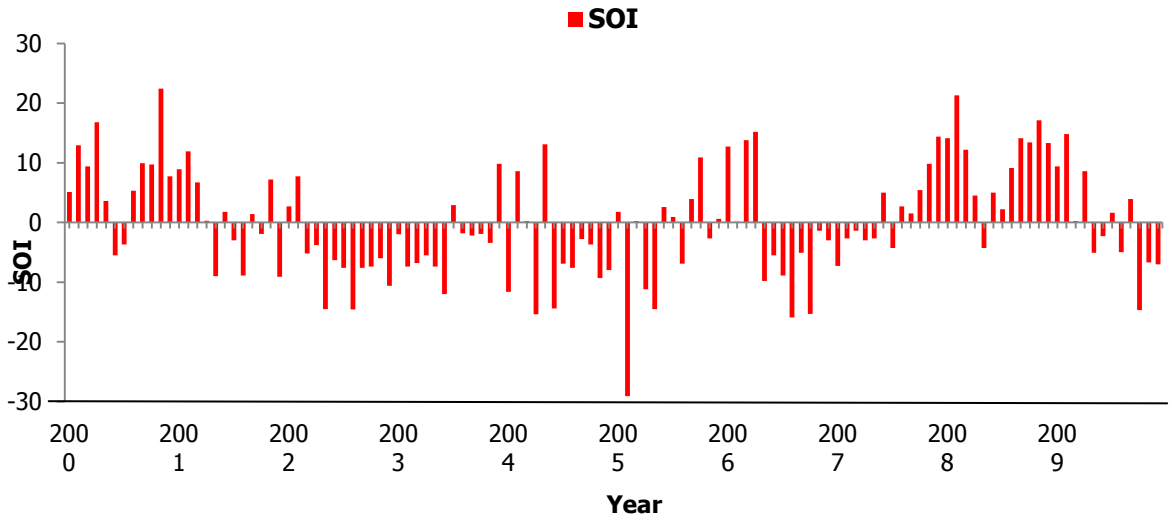

Figure 1.SOI values from 2000 to 2009.

Besides using SOI values as the indicator of ENSO events, changes of rainfall and temperature are the other parameters used to observe the impacts of ENSO events. Figure 2 shows the SOI values and rainfall in the West Coast of Sabah for the last decade. It is obvious that during negative SOI periods (El Niño), the areas experience rainfall deficit. In contrast, during the periods with positive SOI values (La Niña), the rainfall is greatly enhanced (Nicholson & Kim,1997; Arrifin bin Tawang*et al*., 2001; NOAA, 2005).

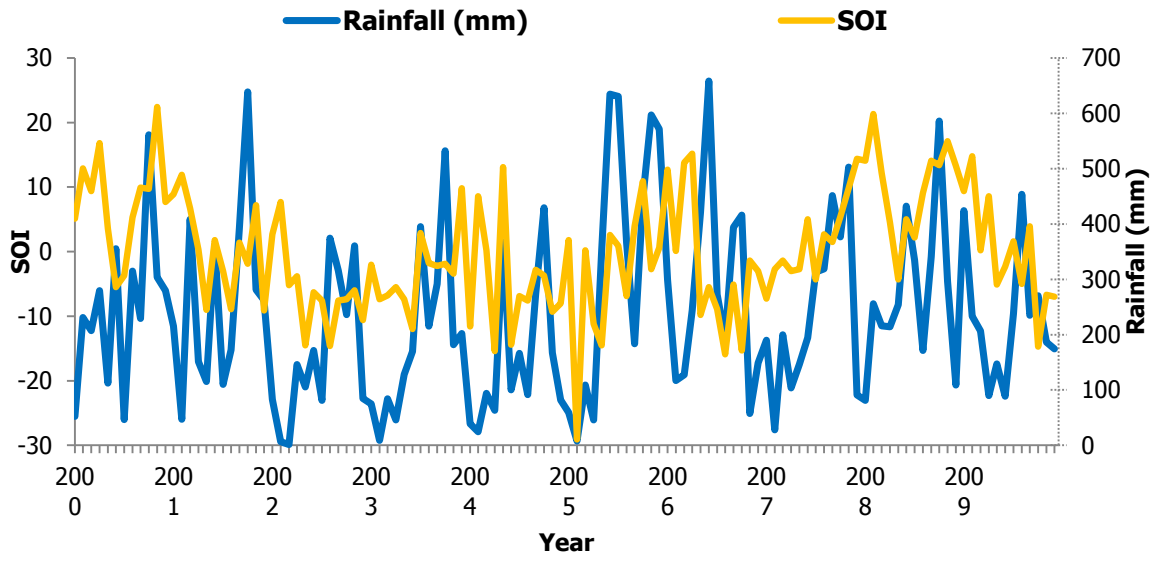

Figure 2.SOI values and monthly rainfall in West Coast of Sabah from 2000 to 2009.

The SOI values and monthly average temperature in the West Coast of Sabah from 2000 to 2009 are shown in Figure 3. It is to be noted that during the periods with negative SOI values, the affected area experiences higher temperature, conversely, periods with positive SOI values generally faces lower temperature. Thus, it is true to say that during El Niño periods, it results in dry weather and subsequently higher temperature, while during La Niña periods, the temperature performs in more pleasant condition (Ariffin bin Tawang*et al*., 2001; Fredolin&Alui, 2002).

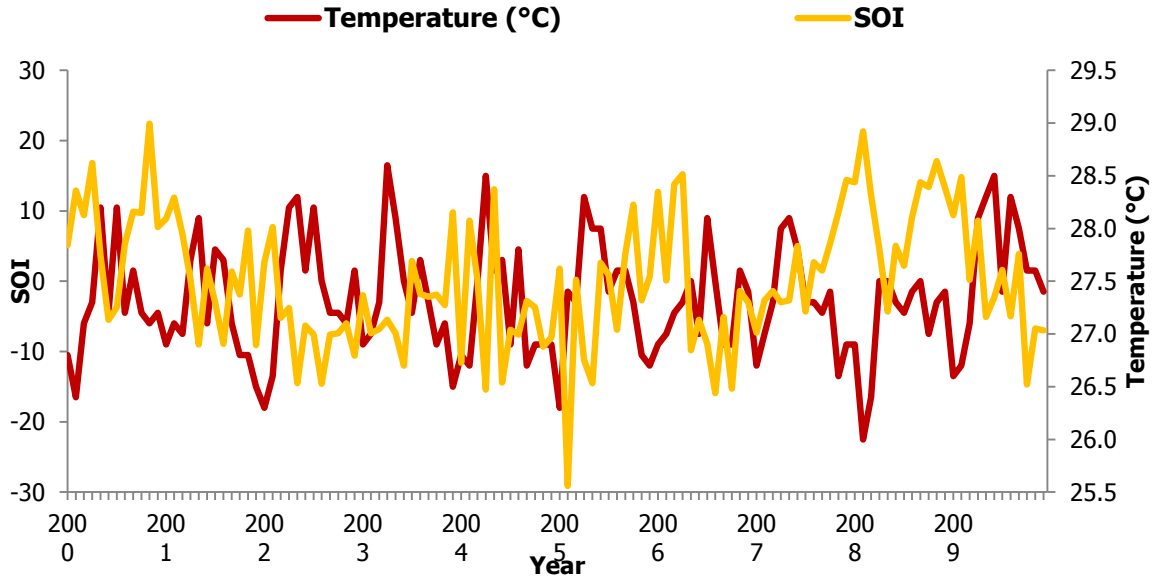

Figure 3.SOI values and monthly average temperature in West Coast of Sabah from 2000 to 2009.

Fish Landings

Fish landing data in the West Coast of Sabah were analyzed for the last decade. It is important to differentiate between fish landings and fish catch whereby fish landing data is obtained once the fish has landed and recorded at the port, while fish catch is the total catches by fishermen. Fish catch may not be similar to fish landings because once the fish have been caught by fishermen, not all catches are landed at the port. Some may be consumed by the fishermen themselves or sold to others before the catches reach the port.

Fish landings with rainfall, fish landings with temperature and fish landings with SOI values in the West Coast of Sabah from 2000 to 2009 are shown in Figures 4, 5 and 6 respectively. It is to be noted that every end of the year, typically after October, fish landings tend to decrease as trade winds weaken. At the beginning of the year, from January to March, fish landings tend to increase drastically as trade winds pick up again. The changes of trade winds strengthen in the neutral years.

Fish Landings and Rainfall

The monthly rainfall and fish landings in the West Coast of Sabah from 2000 to 2009 are shown in Figure 4. The monthly rainfall in the West Coast of Sabah ranges from 0 to 600 mm. it is clear that monthly rainfall of more than 600 mm does not favor the fish landings whereby higher fish landings are generally found in the record of monthly rainfall less than 600 mm. Also, significant rainfall deficit observed during end of the year, typically during the Northeast Monsoon contributes to the reduction of fish landings in the West Coast of Sabah. In overall, increase of rainfall yields in higher fish catch and the effect of rainfall on catch had been reported on both marine and estuarine species (Marten &Guluka, 1974; Chen *et al*., 1994; Esmaeili&Ishak Omar, 2003; Meyneck*et al*., 2006). The increase of rainfall not only decreases the salinity of the water through the inflow of freshwater, but it also increases the flow of terrestrial nutrients into the ocean that serve as suitable food sources for larvae, juveniles as well as large fish.

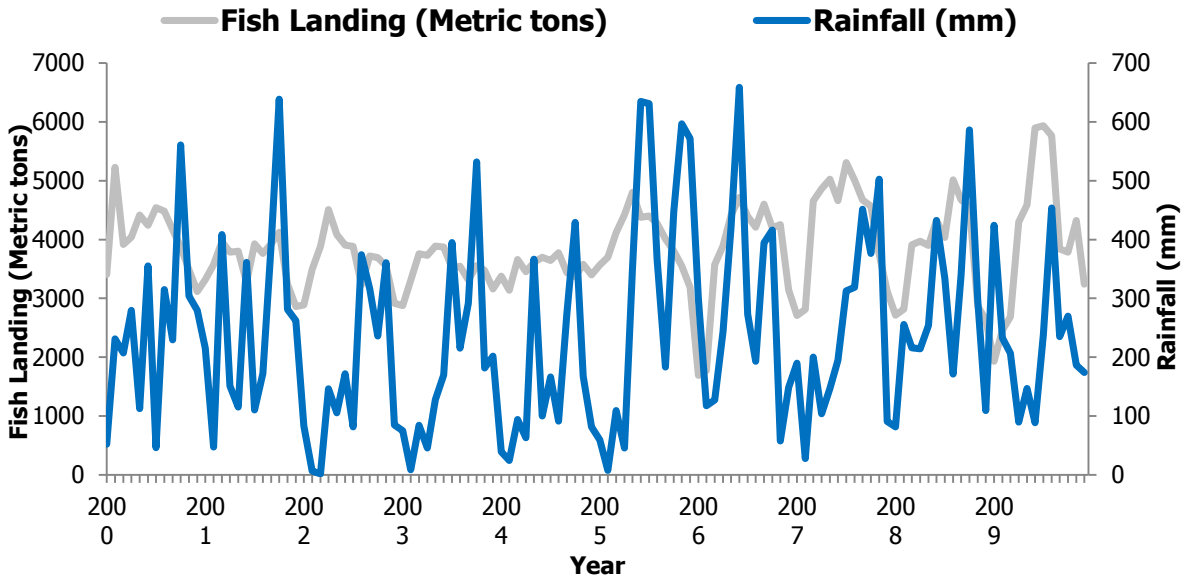

Figure 4.Monthly rainfall and fish landing in West Coast of Sabah from 2000 to 2009.

Fish Landings and Temperature

The monthly average temperature and fish landings in the West Coast of Sabah from 2000 to 2009 are shown in Figure 5. The temperature in the West Coast of Sabah ranges from 26 to 28.5 °C with no drastic changes. Generally, the changes of fish landings are quite consistent to the changes of temperature whereby increasing of temperature yield in higher fish landings (IPCC, 2010). Also, it is important to note that before temperature reduces, fish landings tend to decrease first. In overall, changes in climatic conditions especially air temperature may affect the fisheries by altering the habitat availability and quality.

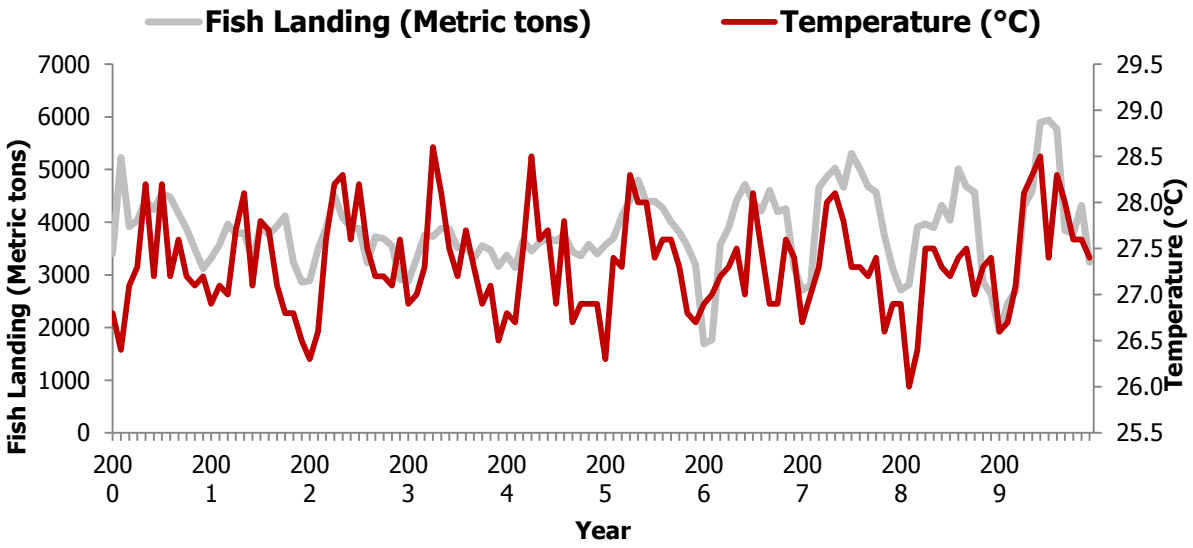

Figure 5.Monthly average temperature and fish landing in West Coast of Sabah from 2000 to 2009.

Warming of air temperature may increase the water temperature thus affect the fisheries habitats (Robert *et al*., 1998). Either marine or riverine fish has different thermal adaptations in the water. Any changes on the temperature may favor the productivity of a fish species but put an adverse impact on another species due to their different physiology adaptations on temperature.

Fish Landings and SOI

The influence of SOI on fish landings in the West Coast of Sabah is observed throughout the 10-year period. Figure 6 depicts the SOI values and fish landings in the West Coast of Sabah from 2000 to 2009. In overall, El Niño periods with negative SOI values favor higher fish landings while La Niña periods with positive SOI values experience lower fish landings. This result is consistent with the study by Aaheim&Sygna (2000) who studied on the impacts of climate change on tuna fisheries in Fiji Islands and Kiribati. During the study, they found out that strong El Niño leads to an increase of tuna catch which is up to 10 % of the total catch in Kiribati.

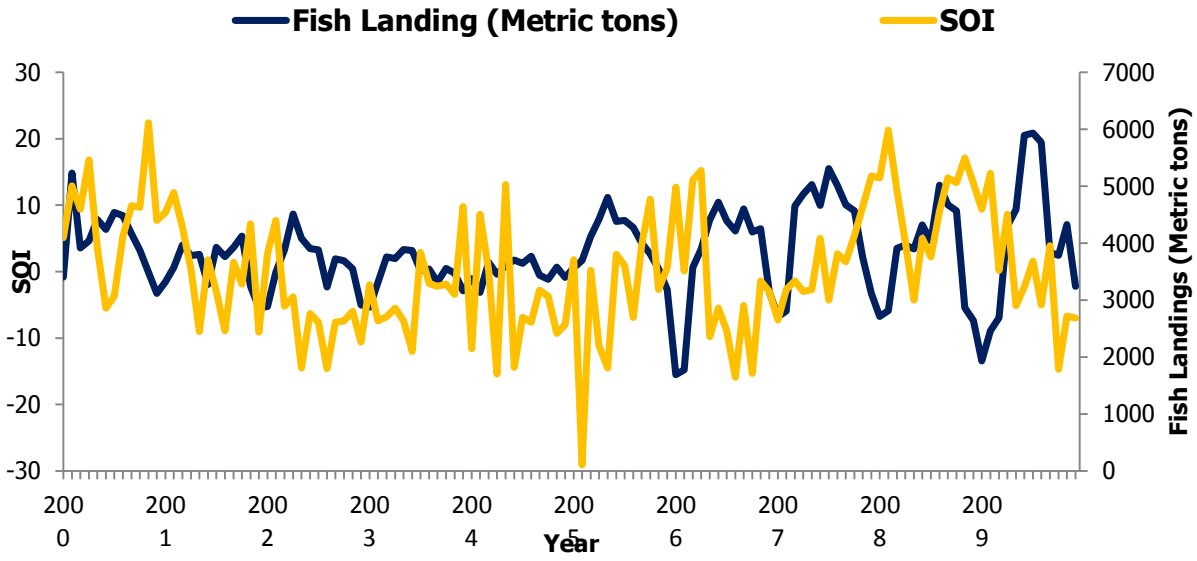

Figure 6.SOI and fish landings in the West Coast of Sabah from 2000 to 2009.

Correlation Coefficients between Time Series of Monthly Fish Landings and Different Variables in the West Coast of Sabah

The results have been further emphasized by a statistical analysis to find out the correlation coefficients with time lag between fish landings with different variables in the West Coast of Sabah in 10-year study period, shown in Figure 7.

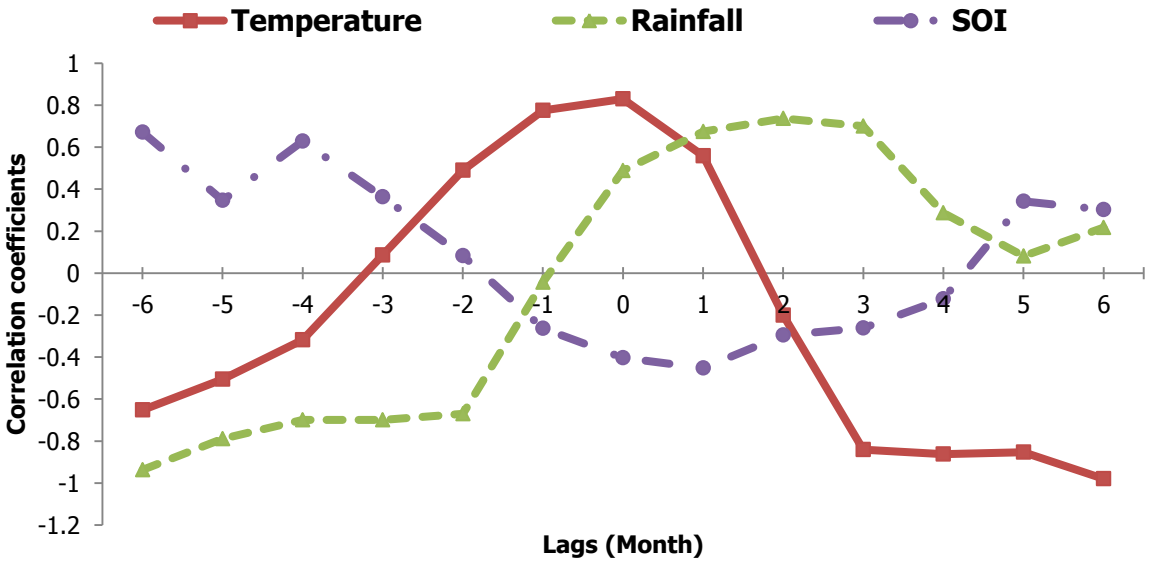

Figure 7.Correlation coefficients between time series of monthly fish landings and different variables in West Coast of Sabah.

Based upon Figure 7, when rainfall is considered, the correlation coefficient of fish landings and rainfall in the West Coast of Sabah is +0.74 with fish landings lead by 2 months. Also, the correlation coefficient between fish landings and temperature is +0.83 at zero time lag. This means that temperature and fish landings are directly correlated in the West Coast of Sabah

for the last decade. Nevertheless, the correlation coefficient of fish landings and SOI is -0.45 with fish landings lead by 1 month whereby negative SOI values (El Niño periods) indicate higher fish landings along the West Coast of Sabah.

The variation of SOI is always associated with the changes of rainfall and temperature. These two parameters are the main variables in affecting the fish landings and play important roles in the fisheries sector. This also indicates that a good understanding on ENSO phenomenon that reflects on rainfall and temperature may influence the fisheries activity as it is able to predict the location and types of fishing gear used in order to obtain more catches.

Production of Palm Oil FFB

Product from agricultural sector – palm oil is concerned as a case study because the influence of ENSO phenomenon that affect the weather is reflected on the production of crops by affecting the growth of crops and subsequently result in yield reduction (Ariffin bin Tawang*et al*., 2001). Also, livelihood of people in Sabah is greatly affected by this sector as Sabah is the largest palm oil producer in Malaysia.

The production of palm oil is represented by the total weight of the palm oil *fresh fruit bunch* (FFB). The data is expressed in total tones of FFB per month. Higher weight of FFB represents higher water content in the fruit. This means that less crude palm oil (CPO) can be extracted from the fruits.

The production of FFB was analyzed from 2005 to 2010 since earlier data was not available in Malaysian Palm Oil Board (MPOB). Figures 8, 9 and 10 depict the production of FFB with rainfall, production of FFB with temperature and production of FFB with SOI in the West Coast of Sabah from 2005 to 2010. It is clear that the production of FFB peaks at the end of each year and the drops in the following year after the production reaches the peak.

Production of FFB and Rainfall

Based upon Figure 8, it is obvious that the variation of rainfall influences the productivity of palm oil whereby heavy rainfall yields on higher production of FFB. Palm oil is able to tolerate rainfall of minimum 150 mm and up to 420 mm per month, provided the soil is properly drained (Ariffin bin Tawang*et al.*, 2001). This result is consistent to several studies whereby under conditions of greater rainfall, the yield from palm oil is expected to increase. In contrast, under limited water condition, the yield is expected to reduce (Ariffin bin Tawang*et al*., 2001; Cadena*et al*., 2006).

Leaves do not grow when there is no rain. Consequently, the yields from palm oil reduce as leaves and clusters of fruits are absent. In addition, increase of rainfall that results in prolonged flooding may lead to the death of palm oil. Flooding also disrupts the transportation of vehicles into the palm oil estates. When the fruit bunches of palm oil are not collected on time, it may result in over-rippen or rotten of fruits.

Production of FFB and Temperature

Temperature and production of FFB from 2005 to 2010 are shown in Figure 9. In general, low temperature produces higher production (weight) of palm oil while high temperature yields on lower production of FFB. According to the study by Cadena*et al.* (2006), higher air temperature is the most productive condition for palm oil.

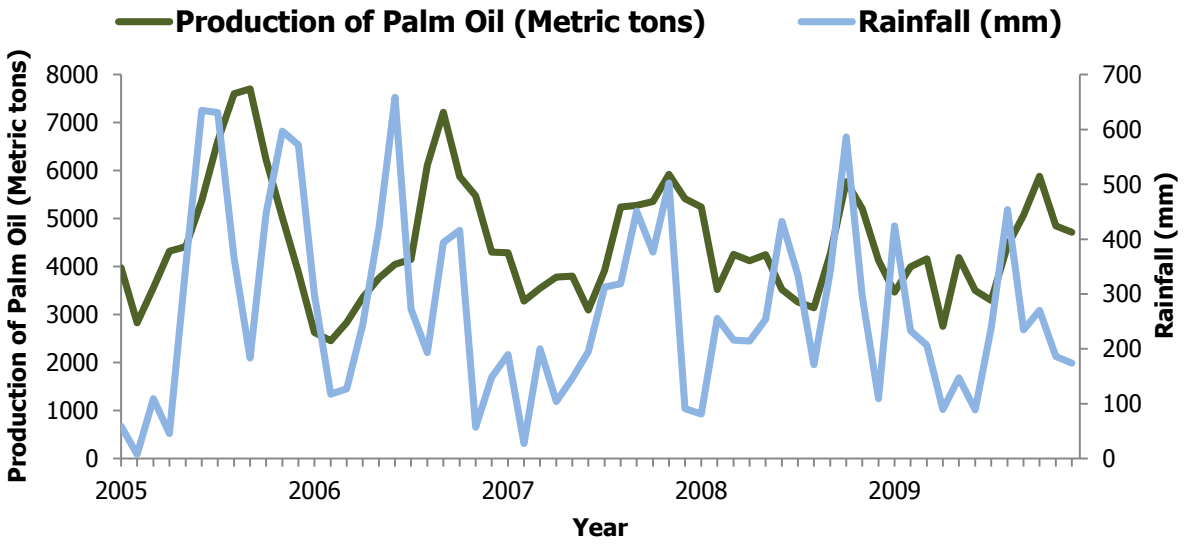

Figure 8.Monthly rainfall and production of FFB of palm oil in West Coast of Sabah from 2005 to 2009.

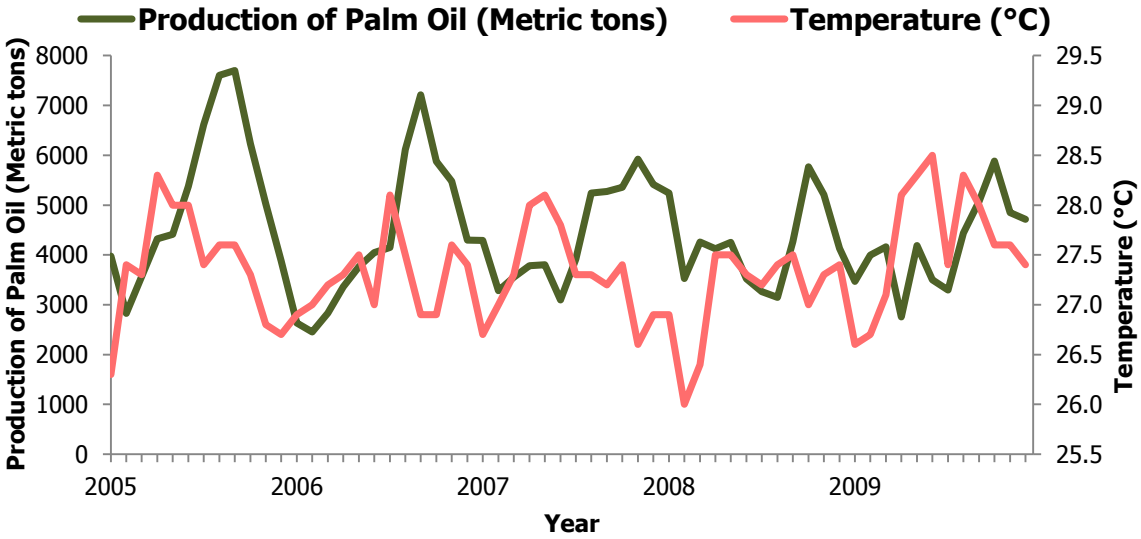

Figure 9.Monthly average temperature and production of FFB of palm oil in West Coast of Sabah from 2005 to 2009.

Hot temperature enables palm oil tree to make many leaves and thus produce many clusters of fruit. If temperature drops, fewer leaves are produced and therefore it yields less. Also, when temperature decreases, palm oil is more vulnerable to be attacked by diseases (Kwasi, 2002).

Production of FFB and SOI

The influence of SOI on the production of FFB in the West Coast of Sabah is shown in Figure 10. Dry weather during El Niño periods has negative impact on the productivity of palm oil (Ariffin bin Tawang*et al.*, 2001). When SOI values become negative, the production of FFB drops drastically. During the dry weather, the size of palm fruits to shrink and become lesser in terms of weightage. The opposite event of El Niño which is the La Niña event produce higher yields of production due to the abundant of rainfall and wet weather. However, too much water can also damage the fruits as palm oil cannot survive long in floods (Palm Oil HQ, 2009; ZaidiIsham Ismail, 2010).

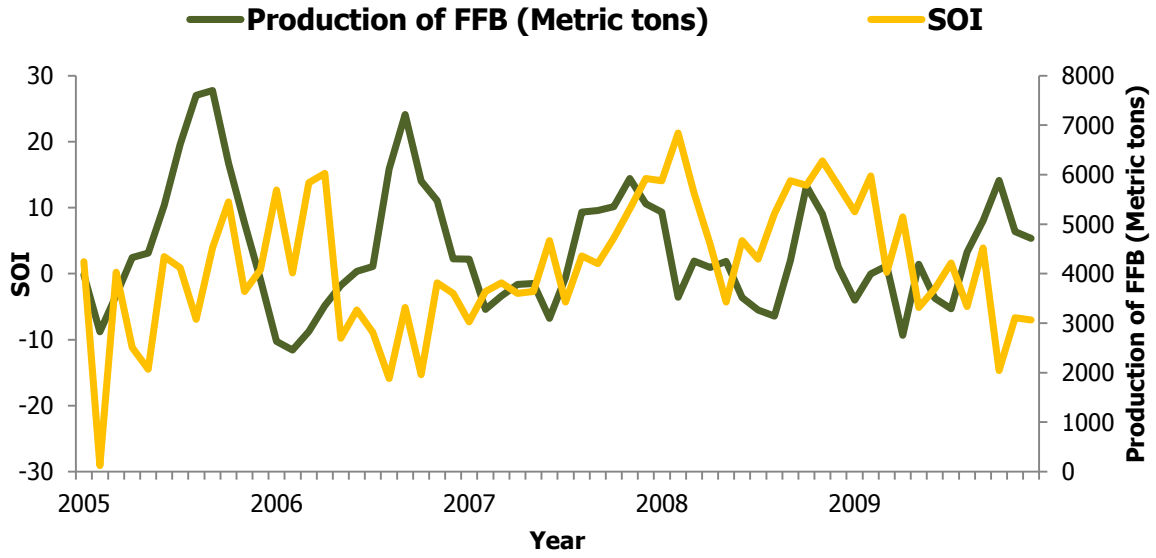

Figure 10. SOI values on the production of FFB of palm oil in West Coast of Sabah from 2005 to 2009.

Correlation Coefficients between Time Series of Monthly Production of Palm Oil FFB and Different Variables in the West Coast of Sabah

To further enhance the above results, statistical analysis is carried out to find out the correlation coefficients together with time lag between the productions of palm oil FFB with different variables in the West Coast of Sabah in 10-year study period, shown in Figure 11.

According to Figure 11, the correlation coefficient between production of FFB and rainfall is +0.83, with rainfall leading by 3 months. When temperature is considered, the correlation coefficient between production of FFB and temperature is +0.87 with temperature leading by 4 months. Also, the correlation coefficient of SOI and production of FFB is +0.62 with production of FFB leading by 3 months. According to Ariffin bin Tawang*et al.*(2001), palm oil is a perennial crop and the real effect of the reduction of yield is expected to come at least one year after any abnormal weather condition occurs. Thus, with the production of FFB leading by 3 months, this also indicates that the production of palm oil has been affected by the changes of previous SOI values, generally 9 months before.

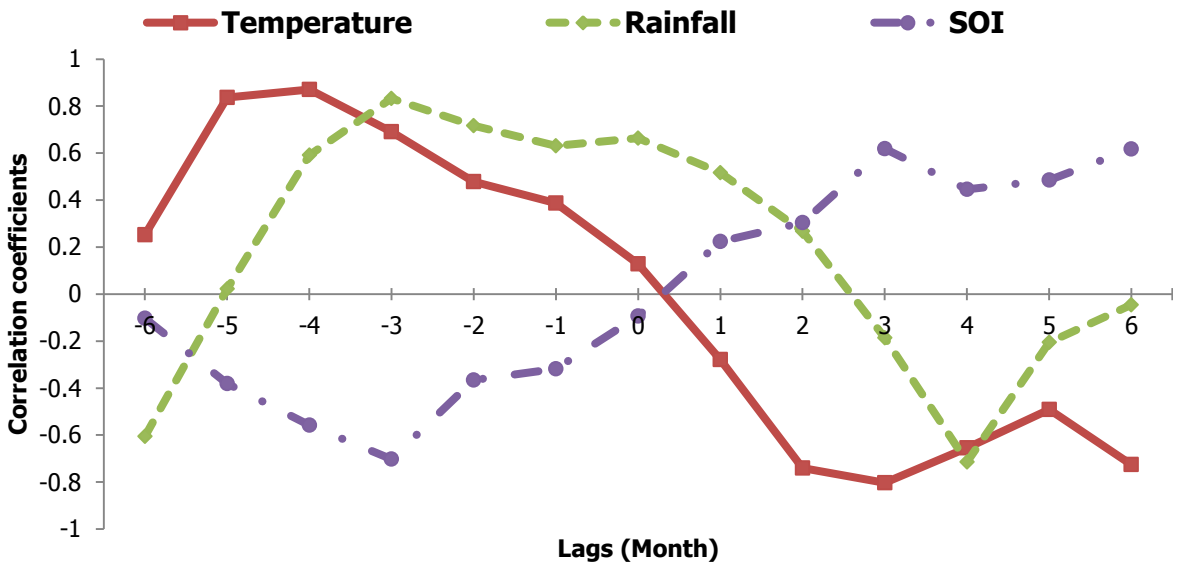

Figure 11.Correlation coefficients between time series of monthly production of palm oil FFB and different variables in West Coast of Sabah.

ENSO phenomenon is a global event that influences the daily activities including fisheries and agriculture activities. It is important to note that the affected areas experience less rainfall and high temperature during El Niño, heavy rainfall and low temperature during La Niña. The effects of ENSO phenomenon on both rainfall and temperature give significant impacts on fish landings and the agricultural products such as production of palm oil FFB in the West Coast of Sabah. Table 1 shows the correlation coefficients between time series of monthly fish landings with different variables in the West Coast of Sabah.

Table 1. Correlation coefficients with time lag between monthly fish landings with different variables.

	Correlation coefficients	Lag (months)
Rainfall	+0.74	2
Temperature	+0.83	0
SOI	-0.45	1

As fisheries sector is one of the most important economies for both local and non local fishermen who depend on Sabah water for their life, it is crucial to ensure that fish landings can be enhanced and sustained under the influences of ENSO phenomenon or other climate changes. By understanding the ENSO phenomenon and subsequent changes of rainfall and temperature along the coast, fish catches and landings may once be improved by locating the most strategic locations for fishing and the most appropriate fishing gear to be used.

Nevertheless, the analysis of correlation coefficients between time series between the productions of FFB with different variables in the West Coast of Sabah is depicted in Table 2.

Table 2. Correlation coefficients with time lag between production of FFB and different variables.

	Correlation coefficients	Lag (months)
Rainfall	+0.83	-3
Temperature	+0.87	-4
SOI	+0.62	3

Based upon the statistical analysis, it has been identified that heavy rainfall and higher temperature favor the production of palm oil. However, if higher rainfall results in flooding and higher temperature results in dry condition, it may not enhance the production of palm oil. Similarly, even though during La Niña events, the production of palm oil increases, higher precipitation that causes flooding may decline the production of palm oil as well as the quality of Crude Palm Oil (CPO) that can be extracted from the fruits.

Fisheries and agriculture industries are both important sectors in sustaining the economy of Sabah. Changes on meteorological variables may alter the production from both sectors, but factors such as over-fishing and pollution cannot be denied. Cooperation and supports from both government and individual sectors are most needed in promoting the development of these sectors. To ensure successful development, there must not only be continuously production, but sustainable development is also needed.

ACKNOWLEDGEMENTS

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