The Economic Impact of the North-east Monsoon and *La Niña* on Oil Palm Production in Malaysia

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ABSTRACT

La Niña, *which occurs during the north-east monsoon season, normally brings higher rainfall than during normal weather in Malaysia. This study shows that* La Niña *had caused flooding in some oil palm planted areas in the past. The floods in effect disrupted harvesting and collecting activities and fresh fruit bunches (FFB) on the oil palm left overripe or become rotten. Crude palm oil (CPO) production declined and reduced income of oil palm growers. The potential losses of FFB by oil palm estates during* La Niña *in 2010 and 2011 were estimated to be about 239 181 t and 224 776 t respectively. In term of potential income losses, they were estimated at RM 155.10 million and RM 168.22 million during the two years. One of the reasons for the increase in the cost of FFB production was the damage of infield roads during floods. Hence, floods affected estates had spent RM 25.80 million and RM 26.48 million to repair the roads in 2010 and 2011 respectively. This study also showed that CPO production depends negatively with a dummy variable used to proxy* La Niña. *In the absence of* La Niña, *CPO production in 2010 should have been around 17.60 million tonnes when the actual CPO production during the year registered at only 16.99 million tonnes. The total potential CPO production loss was estimated to decline by 3.5% and 2.2%, as compared to production without* La Niña *in 2010 and 2011 respectively.*

BACKGROUND

Malaysia is subject to maritime influence and the interplay of wind systems, which originate from the Indian Ocean and South China Sea (Malaysian Metrological Department, 2010). The country faces two monsoons, namely the south-west monsoon from late May to September, and the north-east monsoon or monsoon rains from November to March. The latter brings in more rainfall compared to the former, which originates in China and the north Pacific. It usually hits the east coast of the Peninsular Malaysia, frequently causing widespread floods. Sabah and Sarawak are also affected. However, the south-west monsoon has always been associated with drier weather. The transition period in between these two monsoons (April and October) is known as the inter-monsoon period.

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El Niño happens during the south-west monsoon and it usually refers to sustained differences in the Pacific-Ocean surface temperatures when compared to the average value (Wikipedia, 2011). The accepted definition is a warming or cooling of at least 0.5°C (0.9°F) averaged over the east-central tropical Pacific Ocean. When this happens for less than five months, it is classified as *El Niño*. In Spanish, *El Niño* means 'the little boy'. However, when it happens seven to nine months, it is classified as *La Niña*. The name of *La Niña* also originates from Spanish, meaning 'the little girl'. According to the Malaysian Meteorological Department (2010), *La Niña* is caused by a cooling of the Pacific Ocean and causing higher rainfall compared to normal weather. When average rainfall is above annual rainfall by about 39%, it means that *La Niña* has occurred in that year (Mastura, 1999). Normally, this phenomenon happens at irregular intervals of two to seven years and lasts for nine months to two years.

There are three indicators of *La Niña* events. The first is through the Southern Oscillation Index (SOI). The second is based on the Pacific Ocean Sea Surface Temperature (SST). Wet conditions slightly above normal are expected in the Peninsular Malaysia as well as in most areas in Sabah in November and December. During this period, monsoonal flooding is expected in low-lying areas, particularly in Kelantan, Terengganu and Pahang. *Table 1* shows the years of occurrences of *La Niña* in Malaysia.

TABLE 1. *LA NIÑA* YEARS IN MALAYSIA

1970-1971	1973-1974	1975-1976	1988-1989
1998-2000	2006-2007	2010-2011	-

Note: No *La Niña* incident.
Source: Malaysian Meteorological Department (2010).

The annual rainfall in Malaysia normally ranges from 1500 mm to 4000 mm (mean at 3000 mm). The average annual rainfall in Peninsular Malaysia is 2500 mm (Rosmina, 2012). However, the states of Sabah and Sarawak experience more rainfall, averaging annually at 3000 mm and 3500 mm respectively. Heavy rain normally occurs in November in the northern region of Peninsular Malaysia which includes Perlis, Kedah and Perak. The rain continues to spread and causes floods in other states such as Kelantan, Terengganu, Pahang and Johor.

South-east Asia has long experienced a monsoon climate with dry and wet seasons. In the valleys, floodwaters spread over very wide flood plains developed for agriculture, rice paddies, rubber and oil palm. The flooding in oil palm plantation makes harvesting and delivering fresh fruit bunches (FFB) to mills difficult. When the flood stops, the ripe oil palm fruits sent to the market will be overripe or become rotten and leads to financial loss to oil palm planters. This results in losses. However, if annual and cash crops were flooded, higher losses can be expected as compared to perennial crops.

According to Henson *et al.* (2008), a high water table and flooding can reduce oil palm yield. Complete flooding can cause death of young palms, as well as reduce the yield of old palms. According to Mandeep (2010), a monthly average rain accumulation greater than 100 mm, with 53% of the total rainfall occurring during the north-east monsoon season will lead to *La Niña*. Mandeep (2010) also shows that the probability of exceeding average rain rate was found to be significant during *La Niña*.

Palmoilhq.com (2010) indicated that most mature oil palm are able to survive flood conditions for up to two weeks, but prolonged flooding can bring adverse effects on yield. Therefore, crude palm oil (CPO) futures prices ended higher on short covering (normally starting from November) as heavy rains in oil palm growing states may disrupt harvesting activities. The situation may subsequently lead to a drop in production of palm oil in every fourth quarter of the year. This argument is supported by asiaone.com (2007), which explained that Malaysia's palm oil output is likely to fall from November, as floods and heavy rains inundate plantations in key production states.

Dorab Mistry (2010) indicated that in short-term, weather will likely be the main driver of palm oil prices. This is because if there is *La Niña* in coincidence with the monsoon rains at the end of year, palm oil harvesting could be disrupted and the extraction rates could fall. According to Dorab Mistry (2010), Malaysia's palm oil production dropped to 17.20 million tonnes in 2010 from 17.60 million tonnes in 2009 because of the impact of dry weather caused by *El Niño* earlier in 2009 and the likely onset of *La Niña* at the end of the year.

For production of palm oil, yield and oil palm mature areas are normally its two important influencing factors. However, the above review shows that monsoon rains and *La Niña* can be its additional factors as they cause floods in low-lying areas, leading to a decline in its production and loss in income of oil palm growers in Malaysia. So far no comprehensive study has been carried out to estimate production and total loss faced by the oil palm growers when *La Niña* occurs. Based on this development, it is important not to ignore the two additional factors.

This article provides findings on the effects of this *La Niña* on oil palm production and loss in income by oil palm growers in Malaysia. It will explore the impact of north-east monsoon and *La Niña* on CPO production in Malaysia and estimate the total loss faced by oil palm estates if there is *La Niña*. This can be achieved by developing a forecasting model for CPO production while taking into account the *La Niña* event.

METHODOLOGY

This article uses a combination of methodologies which require the collection and analysis of qualitative and quantitative data. The qualitative approach was done through surveys by mail and fax to obtain primary data from oil palm estates that experienced floods and secondary data was gathered from the MPOB database.

Econometric modeling was used in this article to assist and support the findings that *La Niña* will affect negatively the Malaysian oil palm supply and to develop a forecasting model for CPO production based on the occurrence of *La Niña*. The model used monthly and annual data. Monthly data spans from January 1990 to December 2010 and annual data starts from 1975 until 2011. Both types of models had the sole purpose of examining the impact of north-east monsoon and *La Niña* on CPO production in Malaysia.

a) The model's specification using monthly data:

$PDO_t = f\ (PDO_{t-1}, YLD_t, OER_t, DUM_t)$

$PDO_t = \beta_0 + \beta_1 PDO_{t-1} + \beta_2 YLD_t + \beta_3 OER_t - \beta_4 DUM_t$ -------------------------------(1)

where PDO_t = production of CPO (t per month).
YLD_t = yield of FFB (t ha^{-1} per month).
OER_t = oil extraction rate (%).
DUM_t = dummy weather (1= *La Niña*; 0 = no *La Niña*).

b) The model's specification using annual data:

$PDO_t = f\ (AREA_t, MAT_t, YLD_t, OER_t, DUM_t)$

$PDO_{ti} = \beta_0 + \beta_1 AREA_t + \beta_2 MAT_t + \beta_3 YLD_{ti} + \beta_4 OER_{ti} - \beta_5 DUM_t$------------------(2)

where $AREA_t$ = total area of oil palm (ha).
MAT_t = mature area of oil palm (ha).
Other variables as specified as above.

RESULTS AND DISCUSSION

Survey Results

Table 2 shows the number of oil palm estates which were affected by flood in 2010/2011. There were 402 estates which were affected with an area of 428 912 ha. From the survey, 374 of them (or 93.3%) with a total area of 380 441 ha (or 90.9%) responded. The response rate for Kedah, Melaka and Pulau Pinang was 100% each, mainly due to their small number of estates that were affected by flood. Meanwhile, Johor, Perak, Sabah, Pahang, and Sarawak recorded response rates of above 90%.

Table 3 shows the incidence of floods in oil palm estates in 2010 and 2011. The survey found that the flood occurred between January and April and between October and December, the periods during which the north-east monsoon (monsoon rain) and *La Niña* occurred. In 2010, 265 respondents reported that their oil palm estates were affected by flood in January, 161 respondents in February, 85 respondents in March, 44 respondents in April, 109 respondents in October, 259 respondents in November and 363 respondents in December.

In 2011 the majority of the respondents (25.6%) said that floods had occurred in January. In February, there were 235 respondents whose oil palm estates were affected, in March 149 respondents, in April 108 respondents, in October 69 respondents, in November 171 respondents and in December 198 respondents. This survey supports the statement made earlier that *La Niña* occurs during monsoon rain (October - April) causing floods in oil palm planted areas in selected oil palm estates.

Table 4 shows the flood affected areas of oil palm estate respondents according to region. It was found that the affected areas in 2010 and 2011 were 101 982 ha and 84 558 ha respectively. In Peninsular Malaysia, the affected areas in 2010 and 2011 were 36 282 ha and 29 157 ha respectively. In Sabah and Sarawak, the affected

TABLE 2. OIL PALM ESTATE RESPONDENTS

State	Affected oil palm estates		Respondents of the study		% Response	
	No.	ha	No.	ha	No.	ha
Johor	22	22 163	21	20 295	95.5	91.6
Perak	45	32 445	44	30 010	97.8	92.5
Selangor	18	3 829	16	3 248	88.9	84.8
Sabah	137	139 004	131	123 319	95.6	88.7
Pahang	53	64 064	48	54 788	90.6	85.5
Terengganu	22	22 696	19	18 524	86.4	81.6
N. Sembilan	15	9 166	13	8 391	86.7	91.5
Kedah	6	3 982	6	3 982	100.0	100.0
Melaka	2	278	2	278	100.0	100.0
Sarawak	57	110 378	52	99 865	91.2	90.5
Kelantan	23	19 753	20	16 587	87.0	84.0
Pulau Pinang	2	1 154	2	1 154	100.0	100.0
Total	402	428 912	374	380 441	93.3	90.9

TABLE 3. MONTH OF FLOODS OCCURRING AT OIL PALM ESTATES

Month	2010		2011	
	No. of respondents	%	No. of respondents	%
Jan	265	20.6	320	25.6
Feb	161	12.5	235	18.8
Mar	85	6.6	149	11.9
Apr	44	3.4	108	8.6
May	0	0	0	0
Jun	0	0	0	0
Jul	0	0	0	0
Aug	0	0	0	0
Sept	0	0	0	0
Oct	109	8.5	69	5.5
Nov	259	20.1	171	13.7
Dec	363	28.2	198	15.8
Total	1 286	100.0	1 250	100.0

oil palm areas in 2010 were 45 333 ha and 20 366 ha respectively and in 2011 were 41 163 and 14 238 ha. Thus, it may be observed that the flood in 2010 was more serious as compared to that in 2011 as indicated by bigger affected areas.

Table 5 shows the duration of floods when occurred in oil palm planted area as stated by the oil palm estate respondents. The majority of the respondents (34%) stated that the duration of flood occurs during *La Niña* was less than one week (127 respondents). Another, 22.5% or 84 respondents stated that duration of floods was around one week. There was also another 14.4% respondents who stated that the flood occurred around two weeks. However, there were 44 respondents who stated that the duration of floods occurred was more than four weeks.

Table 6 shows the problems faced by the respondents during floods. Harvesting and collecting activities for the majority of the oil palm estates (355 respondents) had been disrupted and 341 respondents stated that their FFB become overripe or rotten in their oil palm due to a delay in harvesting. Another 197 respondents stated that during the floods, the transportation of FFB to the mills was disrupted. Only 130 respondents stated that there was an increase in the cost of FFB production.

Table 7 shows that 355 oil palm estate respondents (94.9%) stated that their harvesting round becomes longer as compared to normal weather. However, 19 of them or 5.1% stated otherwise.

Table 8 shows the comparison between harvesting rounds during normal weather and during *La Niña*. During normal harvesting rounds, there were 21 respondents who harvested for less than 10

TABLE 4. OIL PALM ESTATES AFFECTED BY FLOODS

Year	Peninsula		Sabah		Sarawak		Malaysia	
	No.	ha	No.	ha	No.	ha	No.	ha
2010	187	36 282	127	45 333	49	20 366	363	101 982
2011	163	29 157	121	41 163	41	14 238	325	84 558

TABLE 5. DURATION OF FLOODS IN OIL PALM ESTATES

Duration of flood	No. of respondents	%
Less than 1 week	127	34.0
1 Week	84	22.5
2 Weeks	54	14.4
3 Weeks	36	9.6
4 Weeks	29	7.8
More than 4 weeks	44	11.8
Total	374	100.0

TABLE 6. PROBLEMS FACED BY RESPONDENTS DURING FLOODS

No.	Type of problems	No. of respondents
1.	Disrupt harvesting and collecting of FFB	355
2.	Disrupt transportation of FFB to the mills	197
3.	Increase in cost of FFB production	130
4.	Overripe or rotten of FFB at oil palm	341

Note: FFB – fresh fruit bunches.

TABLE 7. HARVESTING ROUNDS BECOME LONGER DURING *LA NIÑA*

Remarks	No. of respondents	%
Yes	355	94.9
No	19	5.1
Total	374	100.0

TABLE 8. HARVESTING ROUND OF RESPONDENTS UNDER NORMAL WEATHER AND UNDER *LA NIÑA*

No. of days	Harvesting round during normal weather condition		Harvesting round during *La Niña*	
	No. of estates	%	No. of estates	%
Less than 10 days	21	5.6	0	0.0
10 days	70	18.7	23	6.1
11 days	11	2.9	0	0.0
12 days	50	13.4	14	3.7
13 days	15	4.0	0	0.0
14 days	35	9.4	30	8.0
15 days	113	30.2	59	15.8
16 days	45	12.0	39	10.4
17 days	5	1.3	13	3.5
18 days	9	2.4	35	9.4
19 days	0	0.0	14	3.7
20 days	0	0.0	48	12.8
21 days	0	0.0	32	8.6
More than 21 days	0	0.0	67	17.9
Total	374	100.0	374	100.0

days as compared to none during *La Niña*. Another 70 respondents harvested for 10 days per round during normal weather as compared to only 23 respondents during *La Niña*. During normal weather, there were 113 respondents who harvested for 15 days per round as compared to only 59 respondents during *La Niña*. About 48 respondents harvested for 20 days per round during *La Niña* as compared to none during normal weather. There were also 67 respondents who harvested for more than 21 days per round during *La Niña* as compared to none during normal weather.

Table 9 shows 275 oil palm estate respondents agreed that their FFB could still be harvested after

TABLE 9. AFTER FLOOD EFFECT IN HARVESTING FRESH FRUIT BUNCHES (FFB)

Remarks	No. of respondents	%
FFB still can be harvested	275	73.5
FFB could not be harvested anymore	99	26.5
Total	374	100.0

TABLE 10. AVERAGE LOSS DUE TO OVERRIPE FRESH FRUIT BUNCHES (delay of harvesting)

% Loss	No. of respondents	%
Less than 10	0	0.0
10	58	21.1
15	27	9.8
20	50	18.2
25	23	8.4
30	40	14.5
35	7	2.5
40	18	6.5
45	7	2.5
50	39	14.2
More than 50	6	2.2
Total	275	100.0

flooding. However, there were 99 respondents who mentioned that their FFB could not be harvested anymore because they had become rotten.

From 275 oil palm estate respondents in *Table 9*, 21.1% of them stated that their estimated average loss due to overripe FFB (delay of harvesting) was around 10% (*Table 10*). About 18.2% and 14.5% of the respondents stated that their estimated average losses due to overripe of FFB were around 20% and 30% respectively. However, there were 39 oil palm estate respondents stated that their estimated average loss due to overripe FFB was around 50%.

Table 11 shows the average FFB yield and oil extraction rate (OER) from 2009 to 2011 from oil palm estate respondents. In 2009, average FFB yield and OER were 19.52 t ha^{-1} yr^{-1} and 19.37% respectively. However, average FFB yield and OER in 2010 were 21.23 t ha^{-1} yr^{-1} and 19.48% respectively. In 2011, average FFB yield and OER were recorded at 19.26 t ha^{-1} yr^{-1} and 19.31% respectively from 374 respondents.

Table 12 shows the total cost to repair their roads after the floods. In 2010, 186 respondents spent RM 25.80 million to repair their roads, and 180 respondents spent RM 26.48 million in 2011.

The total potential income loss faced by oil palm estate growers can be estimated based on the survey. *Table 13* shows that in 2010 potential FFB yields loss was estimated at 239 181 t with an estimated value of RM 155.10 million and a total expenditure of RM 25.80 million to repair roads damage. This means that the net potential income loss was around RM 180.9 million (RM 155.10 million + RM 25.80 million). In 2011, the potential FFB yield loss was estimated at 224 776 t with an estimated value at RM 168.22 million. Taking into account a total of RM 26.48 million to repair roads this means that the net potential income loss in 2011 was around RM 194.7 million (RM 168.22 million + RM 26.48 million).

TABLE 11. AVERAGE FRESH FRUIT BUNCHES (FFB) YIELD AND OIL EXTRACTION RATE (OER)

Year	FFB yield (t ha^{-1} yr^{-1})	OER (%)
2009	19.52	19.37
2010	21.23	19.48
2011	19.26	19.31

TABLE 12. TOTAL COST TO REPAIR ROADS DUE TO FLOOD

Year	No. of respondents	Total cost (RM)
2010	186	25 797 812
2011	180	26 474 647

Econometric Analysis

From econometric analysis, it shows that *La Niña* has a negative effect on CPO production in

TABLE 13. ESTIMATED POTENTIAL INCOME LOSS FACED BY OIL PALM ESTATE RESPONDENTS DURING *LA NIÑA* EVENT

Month	2010		2011	
	Volume (t)	Value (RM)	Volume (t)	Value (RM)
Jan	53 368	27 164 211	59 262	49 779 774
Feb	32 918	17 018 713	44 313	37 843 649
Mar	11 673	6 034 849	22 951	17 511 684
Apr	5 921	3 090 601	14 533	10 608 804
Oct	14 644	8 989 082	14 123	8 092 765
Nov	37 676	26 599 099	31 848	20 191 662
Dec	82 961	66 203 130	37 745	24 194 807
Total	239 181	155 099 685	224 776	168 223 146

Malaysia. Various models have been developed and diagnostic checks have been carried out to ensure they are not spurious and follow the right econometric assumptions. The diagnostic checks to examine the goodness of the model include:

- the relationship between dependent and independent variables in the model must follow right economic theory;
- the value of R-square (R^2) must be above 0.80;
- the values of *t*-statistics for independent variables or value of *f*-statistic in the model must be significant; and
- value of the Durbin-Watson must be above 1.70 to indicate absence of multicollinearity (based on the Durbin-Watson Statistic Table).

The Model Using Monthly Data

The model using monthly data is as stated in Equation (1). It states that production of CPO is a function of the production of CPO lagged 1, yield of FFB, OER and dummy weather (1 if there is *La Niña* event and 0 if there is no *La Niña* event). The result shows that CPO production was significantly dependent on these variables including the dummy *La Niña*, which shows a negative relationship with CPO production as expected.

$$PDO_t = 0.5962 + 0.4904PDO_{t-1} + 0.5231YLD_t + 2.1128OER_t - 0.0375DUMt \text{--------} (3)$$
$$(1.0729) \quad (9.4370)^{**} \quad (8.2017)^{**} \quad (6.3291)^{**} \quad (-2.5910)^{*}$$

Note: **,* indicate *t*-statistics significance at 1% and 5% respectively
R^2 = 0.9092; *f*-stat = 375.67 (significance at 1%); DW = 1.0971.

Based on diagnostic check, it is found that all independent variables followed the right economic theory with right signs. The value of R^2 was 0.9092 greater than 0.80 and all values of t-statistics and f-statistics are significant. However, the value of the Durbin-Watson statistic is 1.097, less than 1.70. This indicates that the model has multi-collinearity problem (multi-collinearity problem exists due to strong relationship among the independent variables). Therefore, this model will not be further analysed.

Equation (3) was further improved due to multi-collinearity problem. This problem can be solved by dropping one of the independent variables, *i.e.* yield of FFB, leaving only production of CPO lagged 1, OER and dummy weather. The result for the new Equation (4) is as shown.

$$PDO_t = 1.0352 + 0.7841PDO_{t-1} + 0.6776OER_t - 0.1003DUMt \text{-------------------} (4)$$
$$(1.5601) \quad (17.360)^{**} \quad (1.9870)^{*} \quad (-6.8158)^{**}$$

Note: **, * indicate *t*-statistics significance at 1% and 5% respectively
R^2 = 0.8685; *f*-stat = 332.54 (significance at 1%); DW = 1.9691.

Based on the diagnostic check, it was found that all independent variables in Equation (4) followed the right economic assumptions. It shows high R^2 (0.8685) and significant values of *t*-statistics and *f*-statistic. The multi-collinearity problem was solved in this model because of the high value of Durbin-Watson statistics of about 1.9691. Therefore, this

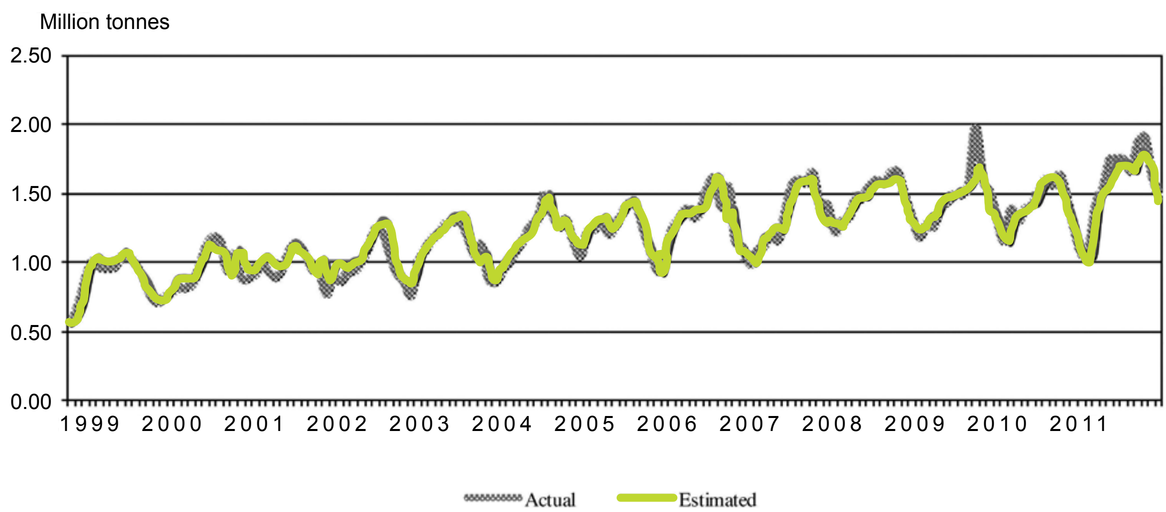

Figure 1. Comparison between actual and estimated values for crude palm oil production.

model is used for further analysis.

Figure 1 shows the comparison between actual and estimated values for CPO production from February 1999 to December 2011, based on Equation (4). The average error of estimating CPO production based on Equation (4) is only 0.36%, giving an indication that this is a good model, which can be used to estimate what is going to happen in CPO production in the future in the event of *La Niña*.

Equation (4) was used to estimate potential CPO production in 2010 which indicated *La Niña* and without *La Niña*. The result is shown in *Table 14*, which shows the comparison between estimated CPO production in January to December 2010 with and without *La Niña*. It shows that CPO production would be 16.62 million tonnes with *La Niña* and 17.60 million tonnes without *La Niña* (a decline in total of 0.98 million tonnes). Thus, on average it shows that during *La Niña* in 2010, total potential CPO production loss estimated at a decline by about 3.5% (17.60 million tonnes *vs.* 16.99 million tonnes) as compared to without *La Niña*.

Table 15 shows the comparison between CPO production in January to December 2011 with and without *La Niña* based Equation (4). It shows that CPO production would be 18.29 million tonnes with *La Niña* and 19.34 million tonnes without *La Niña* (decline in total of 0.87 million tonnes). According to the Malaysian Meteorological Department, 2011 was a *La Niña* year. Therefore, the total potential decline in CPO production due to *La Niña* was 3.3% (19.34 million tonnes *vs.* 18.91 million tonnes).

Equation (4) was also used to forecast CPO production in 2012 under the two scenarios, with and without *La Niña* (*Table 16*). With *La Niña*, it is estimated that the Malaysian CPO production will be 17.12 million tonnes and in the absence of the *La Niña* event, it is estimated at 18.08 million tonnes. However, based on the Malaysian Meteorological Department (2012) is not *La Niña* year. Therefore, Malaysian CPO production in 2012 is estimated at 18.08 million tonnes. The average error of estimating CPO production (January - May) is at 1.53% (based on the model without *La Niña*).

The Model Using Annual Data

The specification of the model using annual data is as stated in Equation (2). It states that production of CPO depends on the planted area of oil palm, mature area of oil palm, OER, yield of FFB and dummy weather. The result of regression is as shown.

$$PDO_t = -5.8758 + 1.0086AREA_t + 0.2160MAT_t + 0.6865OER_t + 0.5790YLD - 0.0121DUM_t \quad (5)$$

(-7.4806)** (5.7016)** (1.4067) (2.3944)* (5.8486)** (-0.7202)

Note: R^2 = 0.9976; *f*-statistic = 2592 (significance at 1%); DW = 1.4425.

Based on *f*-statistic, it shows that all the independent variables can be included in Model 3. Although the model is significant, its *t*-statistics shows that only planted area of oil palm, OER and yield of FFB are significant while oil palm mature area and dummy variable are insignificant. The coefficient for *La Niña* shows a negative relationship with CPO production and consistent with the monthly data analysis. Diagnostic checks show that all independent variables in the model have followed the right economic theory. The value of R^2 is above 0.80 but Durbin-Watson statistic is less than 1.70. This indicates that there was a multi-collinearity problem.

Equation (5) was further improved to solve the multi-collinearity problem. As stated earlier, the problem existed due to the strong relationships among independent variables. Therefore, one of the independent variables in the model had to be dropped. Consequently, this new Equation (6) states that the production of CPO depends only on the area of oil palm, mature area of oil palm, OER and dummy weather. The result of the regression is as shown.

$$PDO_t = -4.1902 + 0.7069AREA_t + 0.4951MAT_t + 0.8203OER_t - 0.0253\,DUM_t \quad (6)$$

(-4.0173)*** (2.9266)*** (2.3762)** (2.0205)* (-1.0636)

Note: ***,** and * indicate that *t*-statistics significance at 1%, 5% and 10% respectively. R^2 = 0.9950; *f*-stat = 1586 (significance at 1%); DW = 2.0501.

Based on the diagnostic checks, it was found that the all independent variables in Equation (6) have followed the right economic theory, while the value of R^2 also is above 0.80. The values of *t*-statistics for area, mature area and OER in the model were significant and the value of *f*-statistic was also significant at 1%. The multi-collinearity problem was solved as the value of Durbin-Watson statistic is above 1.70. Therefore, this model will be used for further analysis.

Figure 2 shows the comparison between actual and estimated values for CPO production from 1975 to 2011 based on Equation (6). The

TABLE 14. ESTIMATED CRUDE PALM OIL PRODUCTION (with and without *La Niña*) IN 2010

Month	With *La Niña* (t)	Without *La Niña* (t)	Diff. (t)	Actual in 2010 (t)	% Error*
Jan	1 386 502	1 532 781	(146 279)	1 321 043	4.92
Feb	1 259 229	1 392 081	(132 852)	1 156 814	8.85
Mar	1 128 487	1 247 545	(119 058)	1 387 234	-18.65
Apr	1 289 292	1 425 315	(136 024)	1 306 228	-1.30
May	1 358 733	1 358 733	-	1 385 424	-1.93
Jun	1 411 097	1 411 097	-	1 420 062	0.63
Jul	1 419 311	1 419 311	-	1 518 753	-6.55
Aug	1 531 239	1 531 239	-	1 606 563	-4.69
Sep	1 604 466	1 604 466	-	1 562 912	2.66
Oct	1 427 347	1 577 936	(150 589)	1 636 560	-12.78
Nov	1 468 666	1 623 614	(154 948)	1 459 030	0.66
Dec	1 333 319	1 473 987	(140 668)	1 232 607	8.17
Total	16 617 687	17 598 105	(980 418)	16 993 230	-2.21
Average	1 466 509	1 384 807	(140 060)	1 416 103	3.56

Note: *% error based on estimated crude palm oil production with *La Niña* and actual production of crude palm oil in 2010.

TABLE 15. ESTIMATED CRUDE PALM OIL PRODUCTION (with and without *La Niña*) IN 2011

Month	With *La Niña* (t)	Without *La Niña* (t)	Diff. (t)	Actual in 2011 (t)	% Error*
Jan	1 315 226	1 453 986	(138 760)	1 057 961	24.32
Feb	1 273 782	1 408 170	(134 387)	1 094 473	16.38
Mar	1 296 278	1 433 039	(136 761)	1 416 032	-8.46
Apr	1 303 715	1 441 260	(137 545)	1 529 985	-14.79
May	1 544 185	1 544 185	-	1 741 847	-11.35
Jun	1 707 218	1 707 218	-	1 753 191	-2.62
Jul	1 719 894	1 719 894	-	1 751 264	-1.79
Aug	1 718 977	1 718 977	-	1 667 230	3.10
Sep	1 650 693	1 650 693	-	1 869 175	-11.69
Oct	1 640 740	1 813 842	(173 102)	1 908 660	-14.04
Nov	1 662 933	1 838 377	(175 444)	1 627 774	2.16
Dec	1 453 273	1 606 597	(153 324)	1 494 893	-2.78
Total	18 286 915	19 336 237	(1 049 322)	18 912 485	-3.31
Average	1 523 910	1 611 353	(87 444)	1 576 040	-3.31

Note: *% error based on estimated crude palm oil production with *La Niña* and actual production of crude palm oil in 2011.

TABLE 16. ESTIMATED CRUDE PALM OIL PRODUCTION (with and without *La Niña*) IN 2012

Month	With *La Niña* (t)	Without *La Niña* (t)	Diff. (t)	Actual in 2012 (t)	% Error*
Jan	1 227 159	1 342 923	(115 764)	1 288 294	4.24
Feb	1 058 987	1 181 952	(122 966)	1 188 356	-0.54
Mar	1 085 292	1 194 813	(109 522)	1 211 257	-1.39
Apr	1 205 500	1 345 649	(140 149)	1 272 626	5.74
May	1 369 060	1 376 062	-	1 383 735	-0.55
Jun	1 602 365	1 594 168	-	1 470 648	8.40
Jul	1 752 531	1 737 257	-	1 691 947	2.68
Aug	1 754 972	1 777 730	-	-	-
Sep	1 692 916	1 693 272	-	-	-
Oct	1 468 463	1 623 389	(154 926)	-	-
Nov	1 495 894	1 653 715	(157 821)	-	-
Dec	1 405 648	1 553 947	(148 299)	-	-
Total (Jan-Jul)	9 307 896	9 772 824	(488 399)	9 506 863	2.80
Average (Jan-Jul)	1 329 699	1 396 118	(97 680)	1 358 123	2.80
Total (Jan-Dec)	17 118 787	18 074 878	(949 446)	-	-

Note: *=% error based on estimated crude palm oil production without *La Niña* and actual production of crude palm oil in 2012.

TABLE 17. ESTIMATED CRUDE PALM OIL PRODUCTION (with and without *La Niña*) (t)

Year	With *La Niña*	Without *La Niña*	Actual	% Error**
2010	17 570 490	18 241 229	16 993 717	3.39
2011	17 980 097	18 624 565	18 912 721	-4.93
2012*	18 500 211	19 178 080	-	-
2013*	19 083 025	19 777 645	-	-
2014*	19 630 078	20 340 200	-	-
2015*	20 062 220	20 783 771	-	-
2016*	20 473 275	21 205 606	-	-
2017*	20 864 151	21 606 652	-	-
2018*	21 235 773	21 987 870	-	-
2019*	21 589 069	22 350 227	-	-
2020*	21 924 960	22 694 677	-	-

Note: **% error based on estimated crude palm oil production with *La Niña* and actual production of crude palm oil.
* Forecast value for crude palm oil production with and without *La Niña*.

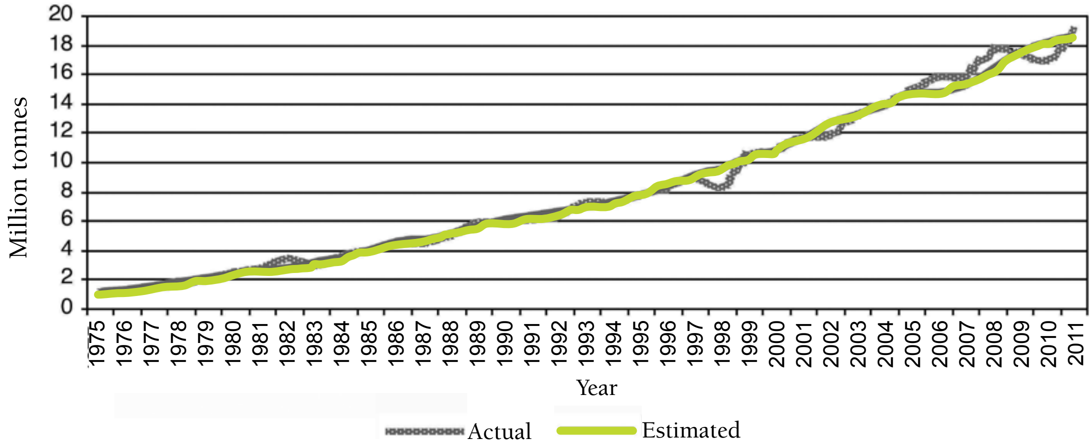

Figure 2. Comparison between actual and estimated values for production of crude palm oil based on Equation (6).

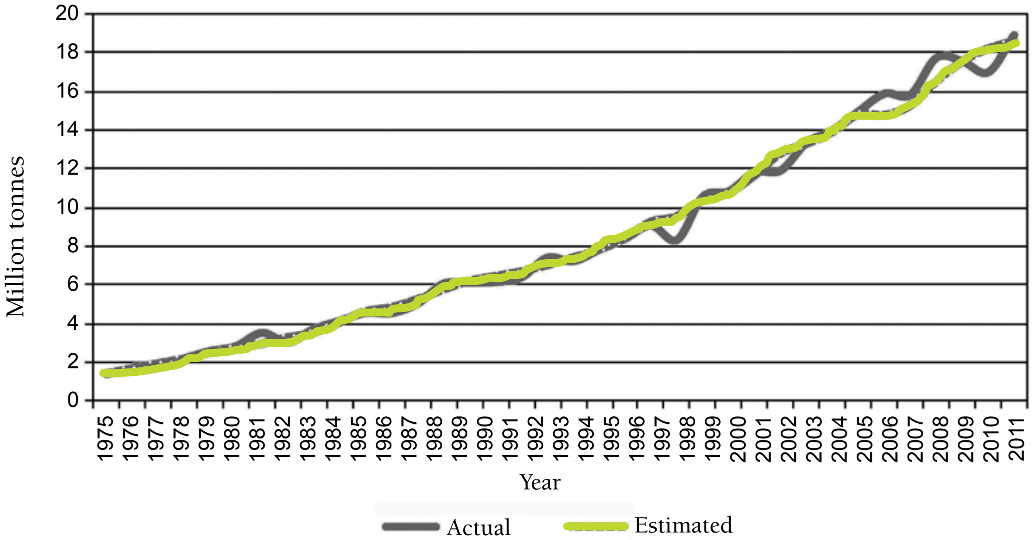

Figure 3. Comparison between actual and estimated production of crude palm oil based on Equation (7).

average error of estimating CPO production is only 4.06%. Due to this, the model can be considered as a good model to be used to estimate what is going to happen in CPO production in the future if *La Niña* and monsoon rain occur in Malaysia.

Table 17 shows the comparison between CPO production with and without *La Niña*, with the inclusion of mature area of affected oil palm estates (based on the survey; mature area affected by flood in 2010 equaled 101 982 ha and 2011 equaled 84 558 ha). It shows that the CPO production in 2010 with and without *La Niña* was estimated at 17.57 million tonnes and 18.24 million tonnes respectively. However, the estimated CPO production in 2011 with and without *La Niña* was 17.98 million tonnes and 18.63 million tonnes respectively. The model gives a moderate error of estimation between CPO production with *La Niña* and actual production in 2010 and 2011 of about 3.39% and 4.93% respectively.

Equation (6) was further improved to lower further the forecasting errors. In this case, additional independent variables in the model would need to be included. Consequently, a new Equation (7) was developed with the production of CPO depends not only on area of oil palm, mature area of oil palm, OER and dummy weather but also on rainfall. The result of regression is as shown.

$$PDO_t = -4.0027 + 0.6406AREA_t + 0.5615MAT_t + 0.8286OER_t - 0.0273DUM_t - 0.0178RAI_t \text{ ------------- (7)}$$

$$(-2.953)^{***} \quad (2.279)^{**} \quad (2.197)^{**} \quad (1.971)^{*} \quad (-1.088) \quad (-0.1628)$$

Note: ***,** and * indicate that *t*-statistics significance at 1%, 5% and 10% respectively. $R^2 = 0.9943$; *f*-stat = 1053 (significance at 1%); DW = 2.0680.

TABLE 18. ESTIMATED CRUDE PALM OIL PRODUCTION (with and without *La Niña*) (t)

Year	With *La Niña*	Without *La Niña*	Actual	% Error**
2010	17 173 788	17 893 578	16 993 717	1.05
2011	18 291 407	19 009 521	18 912 721	-3.29
2012*	18 369 466	19 107 320	-	-
2013*	18 951 281	19 707 302	-	-
2014*	19 500 345	20 273 283	-	-
2015*	19 944 329	20 730 111	-	-
2016*	20 367 666	21 165 595	-	-
2017*	20 771 192	21 580 611	-	-
2018*	21 155 764	21 976 056	-	-
2019*	21 522 244	22 352 831	-	-
2020*	21 871 494	22 711 833	-	-

Note: **% error based on estimated crude palm oil production with *La Niña* and actual production of crude palm oil.
*Forecast value for crude palm oil production with and without *La Niña*.

Based on diagnostic checks, it was found that all the independent variables in Equation (7) have followed the right economic theory. The value of R^2 is also above 0.80 and the t-statistics for area, mature area and OER were significant and the value of *f*-statistic was also significant at 1%. The model has no multi-collinearity as Durbin-Watson statistic is above 1.70. *Figure 3* shows the comparison between actual and estimated values for CPO production based on Equation (7) with average error of 4.01%. The model can be considered as a good fit and can be used to estimate what is going to happen in CPO production in the future in case *La Niña* and monsoon rain occur.

Table 18 shows the comparison between CPO production with and without *La Niña* after including mature area of oil palm estates affected by flood (based on the survey, mature area affected in 2010 equaled 101 982 ha and 2011 equaled 84 558 ha). It shows that the CPO production in 2010 with and without *La Niña* was estimated at 17.17 million tonnes and 17.89 million tonnes respectively. The estimated CPO production in 2011 with and without *La Niña* event was 18.29 million tonnes and 19.01 million tonnes respectively. The model gives a moderate error of estimation with *La Niña* and actual production in 2010 and 2011 of about 1.05% and 3.29% respectively. In terms of the performance regarding accuracy, it proves Equation (7) is much better as compared to Equation (6).

CONCLUSION

La Niña will cause a decline in CPO production in Malaysia. The floods during *La Niña* normally have cut off roads in several states in Malaysia and this caused difficulty in transporting oil palm fruits to the mills. FFB harvesting in Malaysia, the world's second-biggest producer, was disrupted in October to December as *La Niña* had caused flooding in major growing areas. Based on the survey, it was found that *La Niña* had caused floods in oil palm planted areas. FFB would become overripe or rotten due to delays in harvesting. Beside that, the cost of FFB production will also increase due to floods. The results of the empirical study also show that CPO production was significantly dependent on the dummy variable of *La Niña*, which shows a negative relationship with CPO production. The significant contribution from this study is the development of a model to forecast CPO production with the inclusion of *La Niña*. Therefore, it is hoped that a more accurate forecast figure can be produced in the future.

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