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**IMPACT OF *EL NIÑO* / *LA NIÑA* WEATHER EVENTS  
ON THE WORLD COCOA ECONOMY**

## IMPACT OF *EL NIÑO* / *LA NIÑA* WEATHER EVENTS ON THE WORLD COCOA ECONOMY

### EXECUTIVE SUMMARY

1. Cocoa production is highly sensitive to changes in weather conditions. As the weather varies significantly from one season to another, cocoa production has shown a sharp year-on-year change. *El Niño* and *La Niña* are meteorological events affecting rainfall patterns in different parts of the world. In recent years, significant progress has been made in forecasting occurrences of *El Niño* and *La Niña* events. Hence a better understanding of the impact of these weather phenomena on cocoa production would help participants in the cocoa value chain (from cocoa farmers to traders and cocoa-users) in their decision-making processes. This document provides a description of these weather phenomena, information on the geographical areas affected and, finally, examines the historical link between *El Niño* / *La Niña* events and cocoa production, at the world, regional and country levels.

2. Statistical and econometric analyses reveal that *El Niño* events have a significant negative impact on cocoa production. It is estimated that *El Niño* reduces cocoa production, on average, by 2.4% at world level. As expected, Ecuador is the country suffering the most, with cocoa production declining by over six per cent on average. Production in the other major cocoa producing countries is also affected, but to a lesser extent. Indeed, cocoa output falls, on average, by 2.4% in Indonesia, by two per cent in Côte d'Ivoire, by 1.7% in Ghana and by 1.2% in Nigeria. However, the analysis did not reveal any significant impact of *El Niño* events on Cameroon's cocoa output.

3. The statistical and econometric analyses reveal that *La Niña* events have no significant impact on world cocoa production. At the country level, results indicate that production in Papua New Guinea increases by almost 1.7%, most probably due to the reduced impact of pests and diseases.

### INTRODUCTION

4. Cocoa production is highly sensitive to changes in weather conditions: duration and intensity of sunshine and rainfall as well as soil moisture and temperature. As the weather varies significantly from one season to another, cocoa production has shown sharp year-on-year changes. Indeed, according to ICCO Secretariat estimates, changes in global production from previous seasons ranged from -19% (in the 1965/1966 cocoa season) to almost +30% (in 1984/1985). While several factors influence year-on-year production, it is estimated that weather conditions constitute probably the most important one. This document examines the historical impact of the *El Niño* and *La Niña* weather phenomena, the most prominent global year-to-year climate fluctuations on world cocoa production and, by extension, on the world cocoa market.

### PART I: DESCRIPTION OF ENSO EVENTS

#### a) Short description

5. *El Niño* and *La Niña* events are the extremes in a vast repeating cycle of large-scale fluctuations in air pressure called the Southern Oscillation (often referred to as ENSO - *El Niño/La Niña*-Southern Oscillation), *El Niño* being the warm extreme and *La Niña* the cold extreme. The ENSO cycle originates in the tropical Pacific with *El Niño* and *La Niña* events recurring, on average, every four

years (the period can vary between two and seven years) and usually lasting approximately 9 to 12 months. *El Niño* and *La Niña* events have a significant effect on weather patterns in countries such as Indonesia, Papua New Guinea, Ecuador and Peru. However, although they take place in a relatively small portion of the Pacific, the changes caused by the Southern Oscillation can affect patterns of weather variability in large parts of Asia, Africa and North and South America, through teleconnections (cf. hereunder).

6. ENSO events take place in the tropics, a part of the world dominated by prevailing winds, called the trade winds. Near the equator in the tropical Pacific, these easterly (east to west) winds tend to pull the surface water of the ocean along with them, and in particular, the warm surface water westward, to an area that includes Indonesia, eastern Australia and many Pacific Islands. Meanwhile, along the coast of South America, colder water from the ocean depths rises to the top, as the warmer water is blown westward. Since cool air is denser than warm air, it limits the formation of clouds and, therefore, of rainfall.

7. *La Niña*, the cold phase of ENSO, is characterized by stronger-than-normal trade winds, and therefore, as depicted in *Figure 1* in the attached annex, colder tropical Pacific sea surface temperatures (by 1° to 3° celcius), which accentuate the shift in heavy rainfall to the far western tropical Pacific. During *El Niño* events, the trade winds weaken along the equator as atmospheric pressure rises in the western Pacific and falls in the eastern Pacific. Weaker trade winds allow the western Pacific warm water to migrate eastward. *El Niño* episodes reflect periods of exceptionally warm sea surface temperatures (by 2° to 3.5° celcius) across the eastern tropical Pacific.

#### **b) Monitoring and forecasting**

8. Scientists use a variety of tools and techniques to monitor and forecast changes in the Pacific Ocean and the impact of those changes on global weather patterns. In the tropical Pacific Ocean, *El Niño* is detected by many methods, including satellites, moored buoys, drifting buoys, sea level analysis, and expendable buoys. Hence various indicators are used to monitor episodes of *El Niño / La Niña* events.

9. The Southern Oscillation Index (SOI) is one measure of the large-scale fluctuations in air pressure occurring between the western and eastern tropical Pacific (i.e. the state of the Southern Oscillation) during *El Niño* and *La Niña* episodes. Traditionally, this index has been calculated based on the differences in air pressure anomaly between Tahiti and Darwin, Australia. In general, the smoothed time series of the SOI correspond very well with changes in ocean temperatures across the eastern tropical Pacific.

10. While the SOI is a measure based on atmospheric pressure, an ENSO event is also monitored through changes in sea surface temperature (SST). The "normal" conditions are for warmer SSTs to the west of the equatorial Pacific basin and cooler SSTs to the east. During typical *El Niño* conditions, warmer SSTs spread further east, producing the warmer ocean surface temperatures. *La Niña* events are associated with cooler SSTs extending further west and warmer temperatures contracting to the west. There are a variety of techniques for measuring this parameter that can potentially yield different results because different phenomena are actually being measured. The earliest technique for measuring SST was dipping a thermometer into a bucket of water that was manually drawn from the sea surface. Since the 1980s, satellites have been increasingly utilized to measure SST and have

provided an enormous leap in the ability to view the spatial and temporal variation in SST. Measures of SST are reflected in the Optimal Interpolation (OI) datasets, which include *in situ* (ship and buoy) and operational satellite observations, as well as in the extended reconstructed sea surface temperature (ERSST), which excludes operational satellite observations. While the former probably provides a more accurate measure of the SST anomalies, it presents some issues with historical homogeneity.

11. For data sampling of sea surface temperature (SST), the tropical Pacific has been divided into a number of regions named Niño 1, 2, 3, 4, and 3.4 (which encompasses part of both regions 3 and 4), as shown in *Figure 2*.

12. The monitoring and forecasting of the *El Niño* and *La Niña* weather phenomena are undertaken in a number of ways and by numerous organizations with meteorological interests. The meteorological and oceanographic data are drawn from national and international observation systems. Thereafter, complex dynamic models project changes in the tropical Pacific Ocean from its currently observed state. Expert analysis of the current situation adds further value, especially in interpreting the implications of the evolving situation below the ocean surface. Some of the main organizations monitoring and forecasting the evolution of the tropical Pacific Ocean are: the *Australian Bureau of Meteorology* (BoM), the *Climate Prediction Center* (CPC) and *National Weather Service* (NWS) of the *National Oceanic and Atmospheric Administration* (NOAA) of the United States of America, the *European Centre for Medium Range Weather Forecasts* (ECMWF) as well as the *World Meteorological Organization* (WMO) in collaboration with the *International Research Institute for Climate and Society* (IRI).

13. The ability to anticipate ENSO events has been improving in recent years, leading to better management of agriculture, water supplies, fisheries, and other resources. By incorporating climate predictions into management decisions, the negative economic impact of weather conditions can be reduced.

### c) Occurrences

14. The NOAA has developed an index, the Oceanic Niño Index (ONI), for monitoring, assessing, and predicting the occurrence of *El Niño* and *La Niña* events. The ONI is based on sea surface temperature (Extended Reconstructed SST–ERSST.v3b) departures from average in the Niño 3.4 region. It is defined as the three-month running-mean SST departures in the Niño 3.4 region. *El Niño* events are characterized by an ONI equal to or greater than +0.5C while *La Niña* events are characterized by an ONI equal to or less than -0.5C. It should be noted that, to be classified as an *El Niño* or *La Niña* episode, these thresholds must be exceeded for a period of at least five consecutive overlapping three-month periods. Based on this index, 18 *El Niño* and 13 *La Niña* episodes occurred between 1950 and 2010. The list of episodes is presented in *Figure 3*.

15. It should be noted that the 1982-1983 and 1997-1998 *El Niño* episodes were regarded as the most severe. For instance, during the 1982-1983 event, Ecuador and Peru received about seven years' worth of rain in four months, causing damaging floods, while Indonesia and Malaysia suffered from severe droughts and uncontrollable forest fires. The latest *El Niño* event developed in the tropical Pacific in June 2009 and dissipated in May 2010.

#### d) Impact on the weather in cocoa producing countries

16. During cold (*La Niña*) episodes, the patterns of tropical precipitation and atmospheric circulation change. The abnormally cold waters in the equatorial central Pacific lead to lower rainfall in that region, especially during the December – February period. Significant sea surface temperatures and rainfall pattern departures from normal are shown in **Figure 4** in the annex for the Northern Hemisphere winter (December – February) and summer (June – August) seasons. Drier than normal conditions are generally observed in **Ecuador** and north-western **Peru** and in equatorial eastern Africa, including **Uganda**, during the December – February period as well as over southern **Brazil** (below the major cocoa producing states: Bahia, Pará, Rondônia and Espírito Santo) during the June - August period. Simultaneously, wetter than normal conditions develop over **Indonesia**, **Malaysia**, **Papua New Guinea** and the **Philippines**. Increased rainfalls are also observed over northern **Brazil** (above the major cocoa producing states) and **Madagascar** during the December – February period. The Indian monsoon rainfall tends to be larger than normal during the June - August period, especially in northwest **India**, however above the major cocoa producing states: Kerala, Karnataka, Andhra Pradesh and Tamil Nadu.

17. During warm (El Niño) episodes, the patterns of tropical precipitation and atmospheric circulation are also modified. Significant sea surface temperatures and rainfall pattern departures from normal are shown in **Figure 5** in the annex for the Northern Hemisphere winter (December – February) and summer (June – August) seasons. The abnormally warm waters in the equatorial central and eastern Pacific lead to increased rainfall in that region, with wetter than normal conditions observed during the December – February period in **Ecuador**, **Peru**, southern **Brazil** (below the major cocoa producing states: Bahia, Pará, Rondônia and Espírito Santo), and in equatorial eastern Africa, including **Uganda**. Drier than normal conditions generally are observed in **Indonesia**, **Malaysia**, **Papua New Guinea** and the **Philippines**, as well as in northern **Brazil** (above the major cocoa producing states) and **Madagascar**. During the June - August period, the Indian monsoon rainfall tends to be reduced, especially in northwest **India**, however above the major cocoa producing states: Kerala, Karnataka, Andhra Pradesh and Tamil Nadu.

18. A strong direct impact of ENSO events on weather, as shown in **Figures 4** and **5**, excludes West and Central Africa, where the major cocoa producing countries represent in total 70% of global production. However, ENSO events may create anomalous weather patterns over seemingly vast distances (through so-called teleconnections) and, therefore, have an impact on weather conditions in this region, although the signal is not always strong and well defined. Indeed, in particular, a study conducted by the *International Research Institute for Climate and Society* (IRI) (2009) showed that there are enhanced odds of below normal rainfall under *El Niño* episodes in **Côte d’Ivoire** and **Cameroon** in the October – December period, in **Côte d’Ivoire**, **Ghana** and, to a lesser extent, in **Nigeria** in the January – March period and in **Côte d’Ivoire** and **Nigeria** in the July – September period. The largest likelihood concerns Côte d’Ivoire in the January – March period. The increased odds of below normal rainfall under *El Niño* episodes are depicted in **Figure 6**. Moreover, a study from the Research Center on Climatology of the *National Center for Scientific Research* (CNRS) and University of Bourgogne in France showed a correlation between ENSO-related indexes and regional rainfall in West Africa. Additionally, cocoa producing countries in Central America and the Caribbean region are also affected by ENSO events. Increased rainfall is also observed over **Costa Rica** during *La Niña* episodes while, during *El Niño* episodes, drier than normal conditions are generally noted over **Costa Rica**, **Nicaragua** and **Mexico** as well as **Jamaica** and **Haiti**.

## PART II: ENSO EVENTS AND COCOA PRODUCTION

19. As described beforehand, weather conditions in cocoa producing countries are affected by the *El Niño* and *La Niña* weather phenomena. Part II seeks to establish whether a link exists between *El Niño* events and cocoa production and between *La Niña* events and cocoa production.

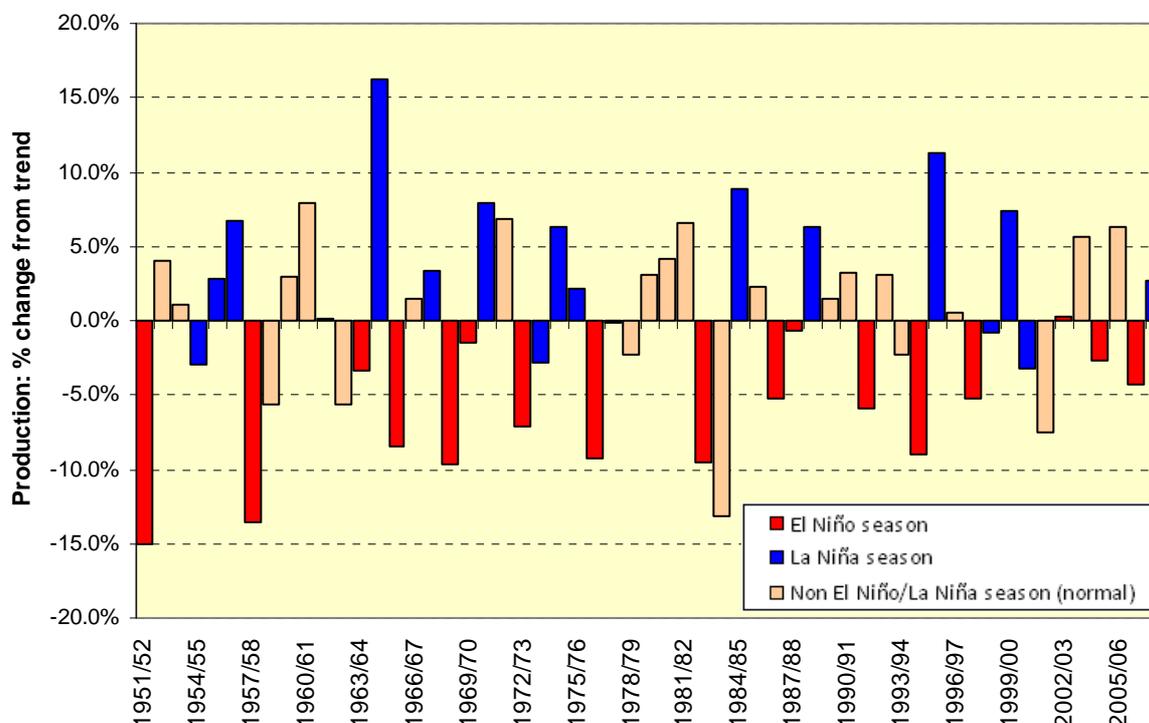
### a) Association of change in global cocoa production with ENSO events

20. As presented in **Figure 3**, 18 *El Niño* and 13 *La Niña* episodes occurred between 1950 and 2010. However, it should be noted that some episodes may potentially affect cocoa production during several seasons, depending on the time of the year as well as on the duration of the events. It takes almost six months for a cocoa pod to develop from flowering to maturity. The cocoa reaches physiological maturity around 150 days after pollination and takes 20-30 days for ripening to complete. Weather conditions have a crucial impact on the production cycle of the cocoa tree from pollination to pod setting; with adequate weather during this period ensuring good survival rates of cherelles and small pods. Most of the cocoa is harvested during the first half of the season (October – March), corresponding to the main crop period in Africa where 70% of the cocoa is produced. Hence, based on these factors, the assumption has been made in the current analysis that ENSO events may have most of their impact on cocoa production of a particular cocoa year if the episode occurs during a period between six months ahead of the start of the cocoa season and the sixth month of the season. For instance, it is estimated that an ENSO event may have a significant impact on the 1972/1973 cocoa year (October 1972 – September 1973) if it occurs between April 1972 and March 1973.

21. **Figure 7** shows that the 17 *El Niño* episodes recorded between 1950 and 2008 (the latest episode has been excluded from the analysis) are estimated to have potentially affected cocoa production during 18 cocoa seasons as the 1986-1988 episode, which lasted about 19 months, covered both the 1986/87 and 1987/88 cocoa years. Similarly, **Figure 8** shows that the 13 *La Niña* episodes recorded between 1950 and 2008 are estimated to have potentially affected cocoa production during 18 cocoa seasons. Indeed, three episodes (the 1954-1957, 1973-1976 and 1998-2000 events) are estimated to have potentially affected eight cocoa seasons.

22. In addition, **Figures 7** and **8** show the change in world cocoa production, in volume and in percentage, during the *El Niño* and *La Niña* seasons respectively, compared to the trend in cocoa production, as measured by a five-year moving average. Similarly, **Chart I**, presented hereafter, associates changes in world cocoa production (i.e. departure from trend) with *El Niño* and *La Niña* seasons.

**Chart I: *El Niño*/*La Niña* episodes and departure from trend of annual cocoa production**



23. Despite the evident limitations of this measure, it is demonstrated that 17 seasons experienced a decline in world production out of the 18 *El Niño* potentially affected seasons. It should be noted that the average decrease in cocoa production during these seasons was 6.5% compared to the trend in production. As presented in **Figure 9**, the Phi coefficient between *El Niño* seasons and normal seasons (without any ENSO events recorded) amounted to -0.72, revealing a strong association of decline in world production with the occurrence of *El Niño* events.

24. Similarly, **Figure 8** reveals that 13 seasons experienced an increase in world production while five seasons experienced a decline in production out of the 18 seasons potentially affected by *La Niña* Events. The calculation of the Phi coefficient between *La Niña* seasons and normal seasons amounted to -0.07, revealing a very weak association of change in production at the global level during the occurrence of *La Niña* events.

#### **b) Assessment of the impact of ENSO events on cocoa production**

25. The core question of this document is to assess whether ENSO events influence the level of cocoa production and, if they do, to quantify their impact. The statistical analysis in the previous sections has shown that the reduction in cocoa production and the occurrence of *El Niño* cannot be considered independent events. Nevertheless, the statistical test does not indicate the existence of a causal relationship between the two nor does it quantify the impact of *El Niño* events on cocoa production. As a result, an econometric exercise should be carried out to test explicitly whether ENSO

events affect cocoa production and, in particular, if *El Niño* events systematically induce a reduction in the volume of cocoa.

26. Ideally, monthly figures on cocoa production and ENSO events should be used. The impact of meteorological events on the production of cocoa strictly depends on their timing, intensity and duration. For example, under the same conditions, adverse meteorological events occurring just before the main season would reduce cocoa production more than what would be the case if they occurred in other periods. Furthermore, meteorological events are extremely volatile. Hence, it is warranted to account for their changes in intensity, duration and occurrence over time. Finally, both cocoa production and meteorological events are characterized by a seasonal pattern.

27. While a rich dataset on ENSO events exists, monthly figures on cocoa production are not available. Indeed, only yearly data on cocoa production are available. Hence important information on these meteorological events (i.e. duration and timing) is lost by averaging the intensity of ENSO events over one year and using yearly production data. With these limitations in mind, the ICCO Secretariat carried out an econometric analysis to assess the impact of *El Niño* / *La Niña* events, as previously defined, on cocoa production.

28. In the econometric exercise, departures of cocoa production from its trend (i.e. observed production minus its five-year moving average) have been matched with the average temperatures of *El Niño* and *La Niña* events. Also the analysis has taken into account the geographical location of cocoa producing countries because of regional difference in ENSO events (i.e. Niño 1, 2, 3, 4, and 3.4; as shown in **Figure 2**). For instance, the Niño 1 and 2 regions were considered for Ecuador while the Niño 3.4 was used for African cocoa producing countries. Furthermore, to account for a lag effect of ENSO events on cocoa production, the annual average temperature has been computed during the period from April to March of the following year. The sample runs from 1950/1951 to 2009/2010.

29. **Figure 10** reports on the estimated results. As expected, Ecuador is the country suffering the most from *El Niño* events. On average, it is estimated that the occurrence of *El Niño* events reduces cocoa production by over six per cent on a yearly basis, whereas its effects are less severe in other cocoa producing countries. For example, the Secretariat estimates that, as result of *El Niño* events, production falls on average by 2.03% and 2.39% in Côte d'Ivoire and Indonesia, respectively. In Ghana, production declines on average by 1.72%. In Nigeria, the fall in production is just above one per cent. However, no cause-effect relationship between *El Niño* events and cocoa production was observed in Cameroon. This may occur because rainfall patterns are less affected in Cameroon by *El Niño* events, as illustrated in **Figure 6**.

30. At the regional level, cocoa production declines by 1.44% and 1.14% in Africa and in the Americas, respectively. The exceptions are Asia and Oceania, where *El Niño* events do not have a statistically significant impact at regional level. It is likely that their effect is watered down by the data aggregation process.

31. Finally, it is estimated that *El Niño* events reduce cocoa production, on average, by 2.43% at world level. As a result of this reduction, world cocoa prices increase by 1.66% on average. At a global level, this partially compensates for the loss in cocoa revenues due to the reduction in volume. However, some countries will be worse off, whereas others will be better off. This occurs because the impact of *El Niño* events is not homogenous across cocoa producing countries. For example, while cocoa prices increase by 1.66%, cocoa production in Ecuador declines by 6.16%. On the other hand, cocoa production in Ghana, Nigeria and Cameroon, to name a few, is not systematically affected by *El Niño* events.

32. Concerning *La Niña* events, results indicate that production in Papua New Guinea increases by nearly 1.68%. What most likely happens is that *La Niña* events, reducing the average temperature, reduce the chances of development and spreading of pests and diseases, *de facto*, increasing yields.

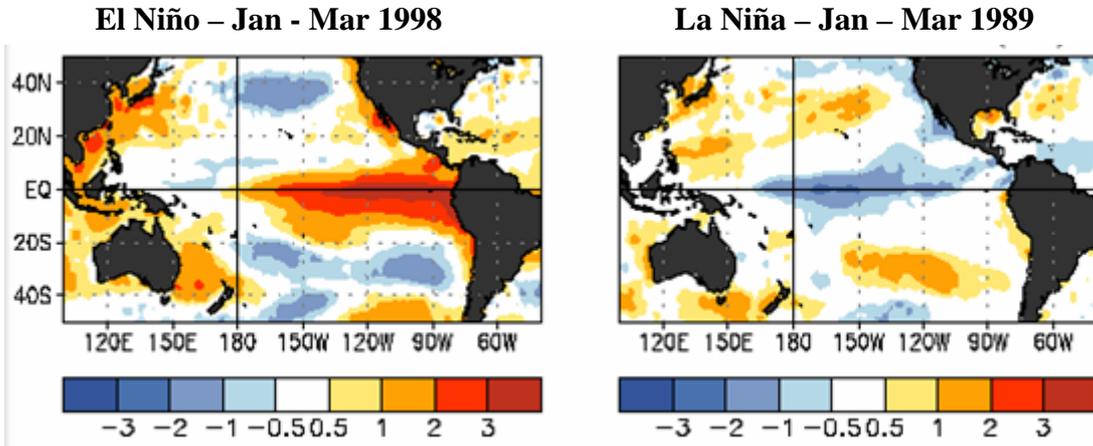
IMPACT OF *EL NIÑO* / *LA NIÑA* WEATHER EVENTS ON THE WORLD COCOA ECONOMY

## ANNEX

## LIST OF FIGURES

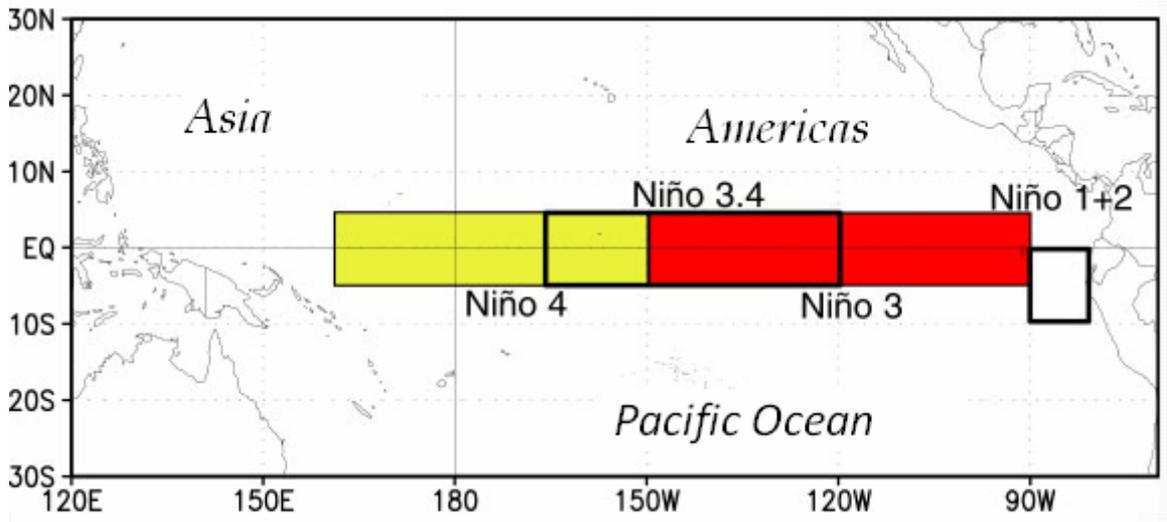
- Figure 1 Ocean temperature departures (°c)
- Figure 2 Graphical depiction of the four Niño regions
- Figure 3 Historical *El Niño* and *La Niña* episodes
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- Figure 8 *La Niña*: episodes and departure from trend of annual cocoa production
- Figure 9 Change in global cocoa production and ENSO events
- Figure 10 Estimated impact of *El Niño* / *La Niña* events on cocoa production

**FIGURE 1**  
**OCEAN TEMPERATURE DEPARTURES (°C)**



Source: United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA)

**FIGURE 2**  
**GRAPHICAL DEPICTION OF THE FOUR NIÑO REGIONS**



Source: United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA)

**FIGURE 3**  
**HISTORICAL EL NIÑO AND LA NIÑA EPISODES**

El Niño	Highest ONI value	La Niña	Lowest ONI value
JAS 1951–NDJ 1951/52	0.8	ASO 1949–FMA 1951	-1.7
MAM 1957–MJJ 1958	1.7	MAM 1954–DJF 1956/57	-2.1
JJA 1963–DJF 1963/64	1.0	ASO 1962–DJF 1962/63	-0.8
MJJ 1965–MAM 1966	1.6	MAM 1964–DJF 1964/65	-1.1
OND 1968–MJJ 1969	1.0	NDJ 1967/68–MAM 1968	-0.9
ASO 1969–DJF 1969/70	0.8	JJA 1970–DJF 1971/72	-1.3
AMJ 1972–FMA 1973	2.1	AMJ 1973–MAM 1976	-2.0
ASO 1976–JFM 1977	0.8	SON 1984–ASO 1985	-1.0
ASO 1977–DJF 1977/78	0.8	AMJ 1988–AMJ 1989	-1.9
AMJ 1982–MJJ 1983	2.3	ASO 1995–FMA 1996	-0.7
JAS 1986–JFM 1988	1.6	JJA 1998–MJJ 2000	-1.6
AMJ 1991–JJA 1992	1.8	SON 2000–JFM 2001	-0.7
AMJ 1994–FMA 1995	1.3	ASO 2007–AMJ 2008	-1.4
AMJ 1997–AMJ 1998	2.5		
AMJ 2002–FMA 2003	1.5		
MJJ 2004–JFM 2005	0.9		
JAS 2006–DJF 2006/07	1.1		
MJJ 2009–Spring 2010	1.8		

*Source: United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA)*

Note:

The Oceanic Niño Index (ONI) is based on sea surface temperature (ERSST.v3b dataset) departures from average in the Niño 3.4 region. It is defined as the three-month running-mean SST departures in the Niño 3.4 region. *El Niño* events are characterized by an ONI greater than or equal to +0.5C while *La Niña* events are characterized by an ONI less than or equal to -0.5C. It should be noted that to be classified as an *El Niño* or *La Niña* episode, these thresholds must be exceeded for a period of at least 5 consecutive overlapping 3-month periods (for instance, JAS 1951 – NDJ 1951/52, the first reported *El Niño* episode, refer to the July-August-September 1951 to November-December-January 1951/52 period).

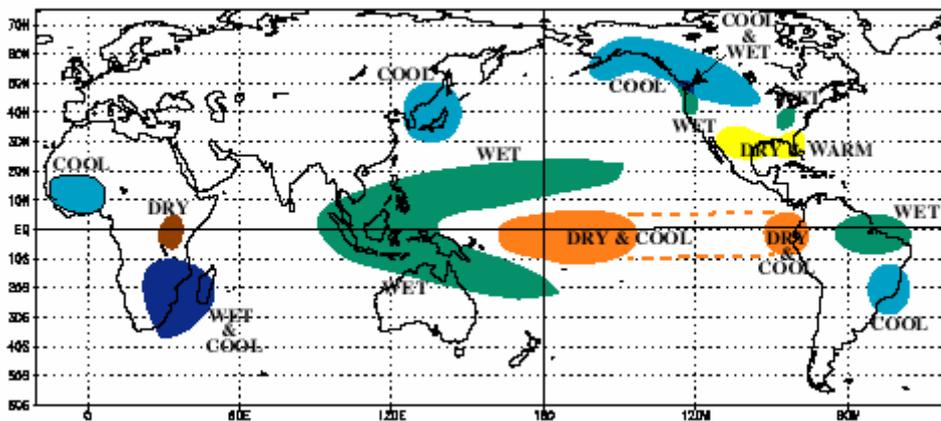
**FIGURE 4**

**LA NIÑA: GLOBAL SURFACE TEMPERATURE AND PRECIPITATION PATTERNS**

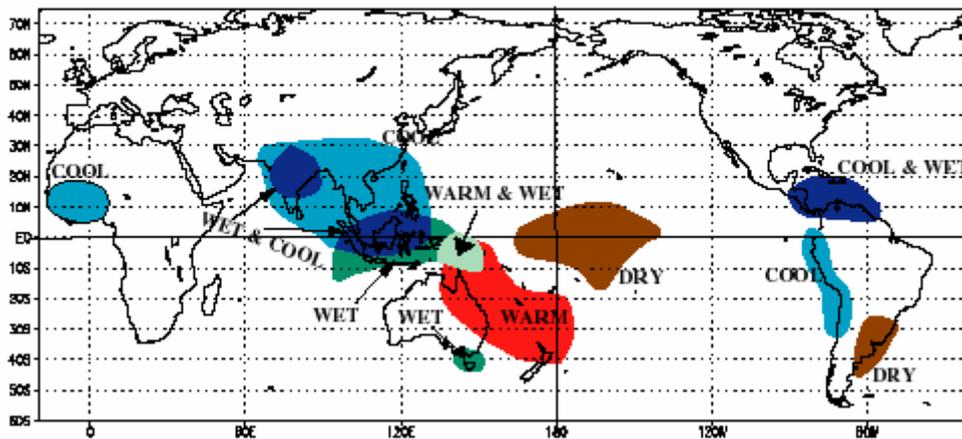
**Direct impacts on cocoa producing areas:**

- *Increased rainfall:* Indonesia, Malaysia, Papua New Guinea and the Philippines
- *Increased rainfall and cooler temperatures:* Madagascar
- *Lower rainfall:* Ecuador, Peru and Uganda

**COLD EPISODE RELATIONSHIPS DECEMBER - FEBRUARY**



**COLD EPISODE RELATIONSHIPS JUNE - AUGUST**



Source: United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA)

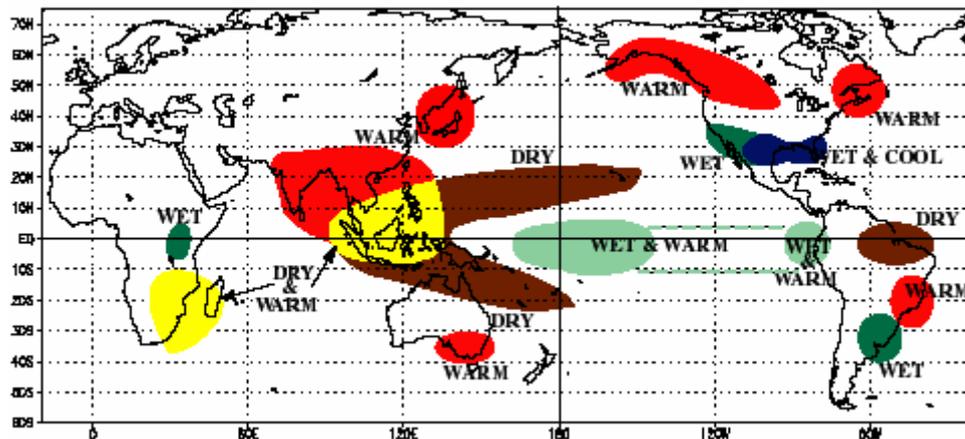
**FIGURE 5**

**EL NIÑO: GLOBAL SURFACE TEMPERATURE AND PRECIPITATION PATTERNS**

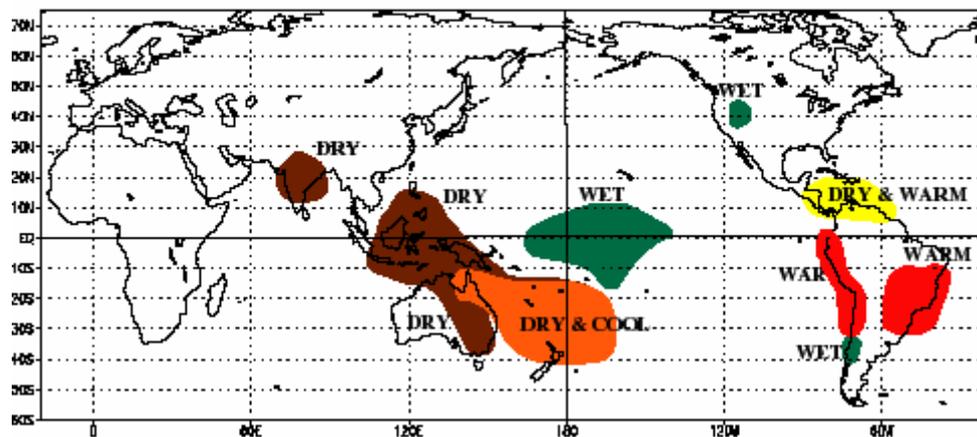
**Direct impacts on cocoa producing areas:**

- Lower rainfall: Indonesia, Malaysia, Papua New Guinea and the Philippines
- Lower rainfall and warmer temperatures: Madagascar
- Increased rainfall: Ecuador, Peru and Uganda

**WARM EPISODE RELATIONSHIPS DECEMBER - FEBRUARY**



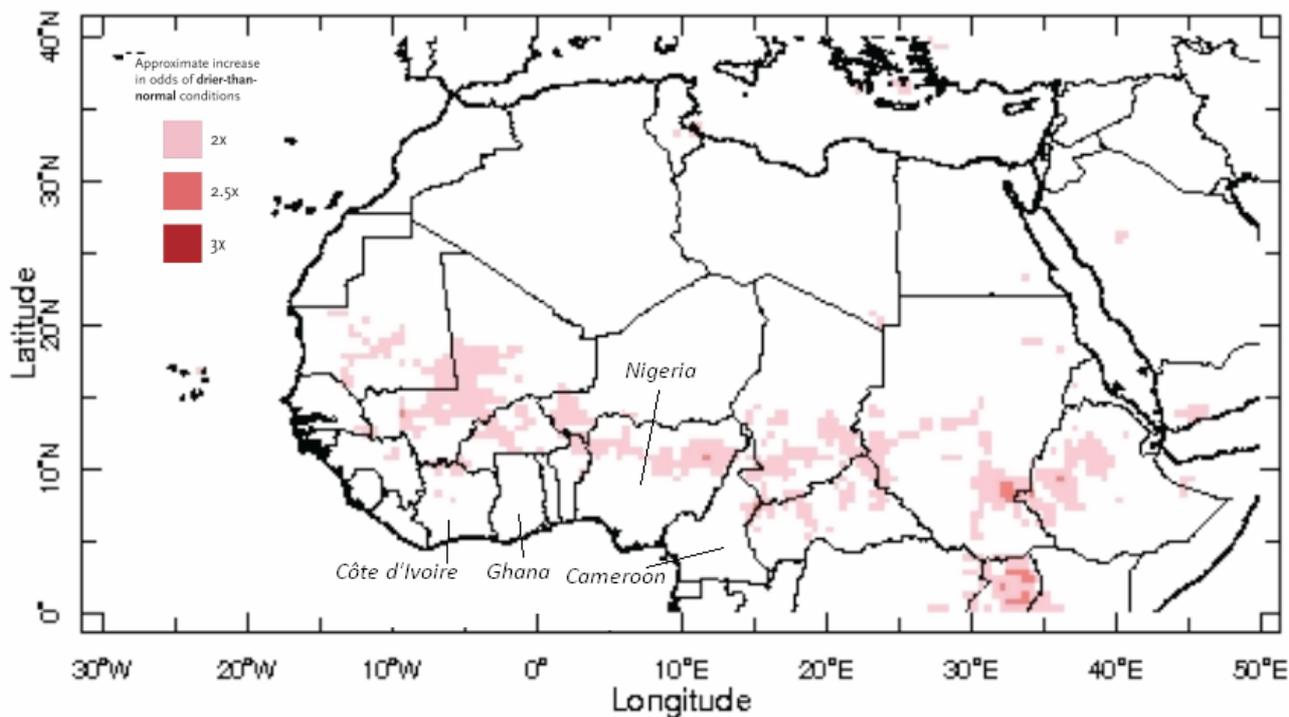
**WARM EPISODE RELATIONSHIPS JUNE - AUGUST**



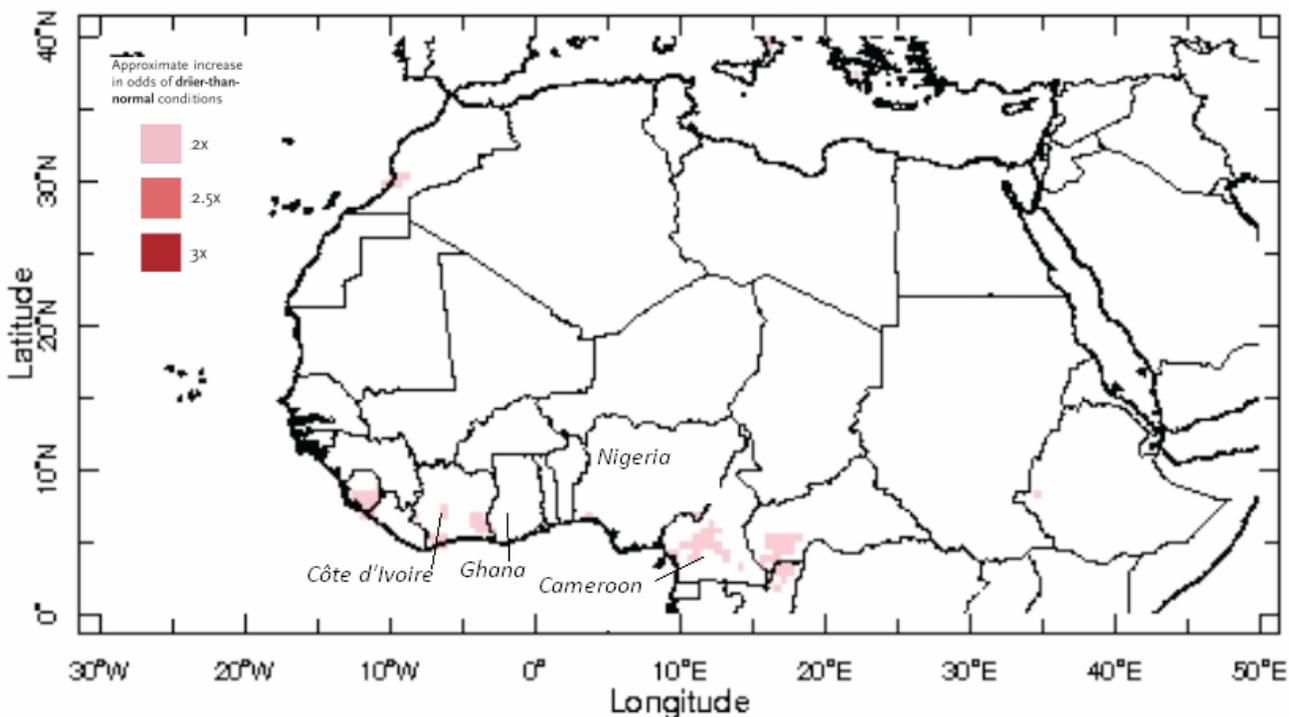
Source: United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA)

**FIGURE 6**  
**EL NIÑO: IMPACT ON PRECIPITATION PATTERNS IN AFRICA**

**JULY - SEPTEMBER**



**OCTOBER - DECEMBER**



**FIGURE 5**  
**CONTD**

**JANUARY - MARCH**

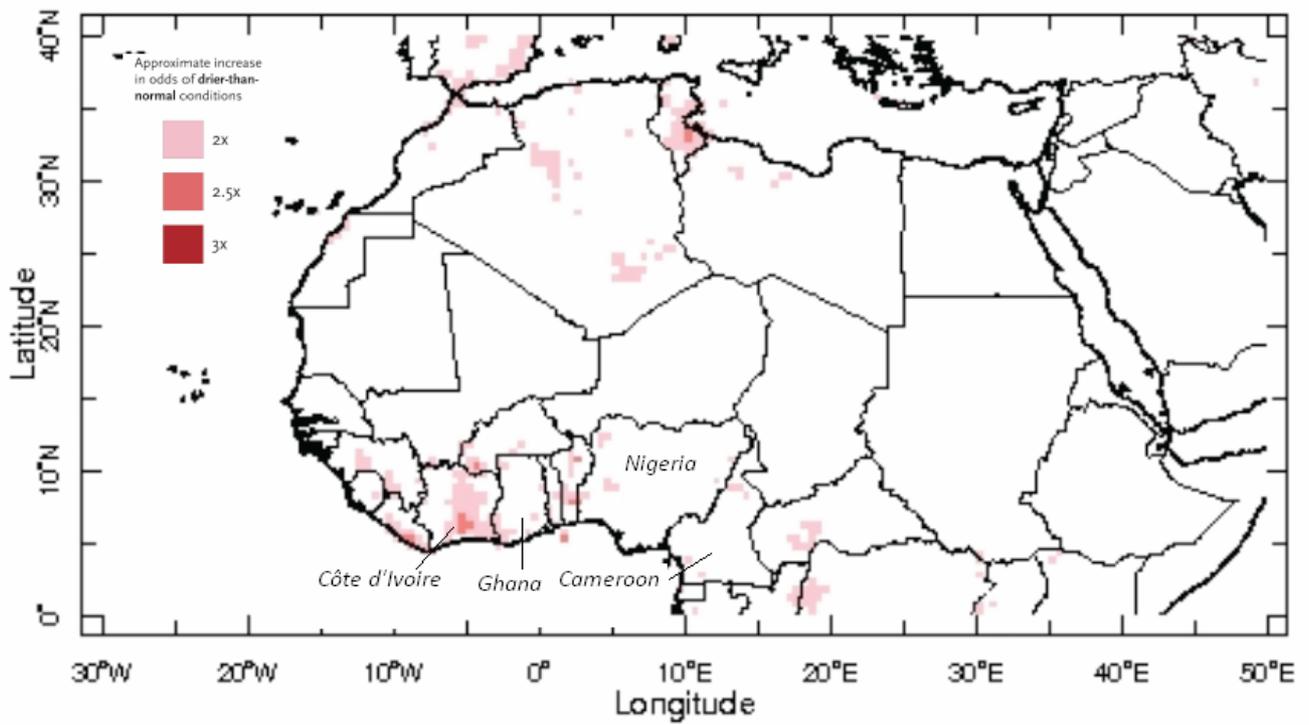


FIGURE 7

**EL NIÑO: EPISODES AND DEPARTURE FROM TREND OF ANNUAL COCOA PRODUCTION**

El Niño periods	Cocoa year	Highest ONI value	Departure from trend, volume ('000 tonnes)	Departure from trend, Percentage
JAS 1951–NDJ 1951/52	1951/52	0.8	-114.2	-15.0%
MAM 1957–MJJ 1958	1957/58	1.7	-120.2	-13.5%
JJA 1963–DJF 1963/64	1963/64	1.0	-41.4	-3.3%
MJJ 1965–MAM 1966	1965/66	1.6	-113.2	-8.5%
OND 1968–MJJ 1969	1968/69	1.0	-135.2	-9.7%
ASO 1969–DJF 1969/70	1969/70	0.8	-21.2	-1.5%
AMJ 1972–FMA 1973	1972/73	2.1	-107.0	-7.1%
ASO 1976–JFM 1977	1976/77	0.8	-136.4	-9.2%
ASO 1977–DJF 1977/78	1977/78	0.8	-1.2	-0.1%
AMJ 1982–MJJ 1983	1982/83	2.3	-159.4	-9.5%
JAS 1986–JFM 1988	1986/87	1.6	-109.6	-5.2%
<i>JAS 1986–JFM 1988</i>	1987/88	1.6	-13.6	-0.6%
AMJ 1991–JJA 1992	1991/92	1.8	-144.2	-6.0%
AMJ 1994–FMA 1995	1994/95	1.3	-230.8	-8.9%
AMJ 1997–AMJ 1998	1997/98	2.5	-147.6	-5.2%
AMJ 2002–FMA 2003	2002/03	1.5	8.4	0.3%
MJJ 2004–JFM 2005	2004/05	0.9	-91.2	-2.6%
JAS 2006–DJF 2006/07	2006/07	1.1	-152.2	-4.2%

**Sources:** United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), International Cocoa Organization (ICCO)

FIGURE 8

**LA NIÑA: EPISODES AND DEPARTURE FROM TREND OF ANNUAL COCOA PRODUCTION**

La Niña periods	Cocoa year	Lowest ONI value	Departure from trend, volume ('000 tonnes)	Departure from trend, Percentage
ASO 1949–FMA 1951	1949/50	-1.7	44.6	6.2%
MAM 1954–DJF 1956/57	1954/55	-2.1	-24.6	-3.0%
<i>MAM 1954–DJF 1956/57</i>	1955/56	-2.1	23.2	2.8%
<i>MAM 1954–DJF 1956/57</i>	1956/57	-2.1	57.0	6.8%
ASO 1962–DJF 1962/63	1962/63	-0.8	-69.6	-5.6%
MAM 1964–DJF 1964/65	1964/65	-1.1	210.6	16.3%
NDJ 1967/68–MAM 1968	1967/68	-0.9	45.0	3.4%
JJA 1970–DJF 1971/72	1970/71	-1.3	114.2	7.9%
AMJ 1973–MAM 1976	1973/74	-2.0	-42.4	-2.8%
<i>AMJ 1973–MAM 1976</i>	1974/75	-2.0	92.0	6.4%
<i>AMJ 1973–MAM 1976</i>	1975/76	-2.0	32.0	2.2%
SON 1984–ASO 1985	1984/85	-1.0	160.2	8.9%
AMJ 1988–AMJ 1989	1988/89	-1.9	147.2	6.4%
ASO 1995–FMA 1996	1995/96	-0.7	294.6	11.2%
JJA 1998–MJJ 2000	1998/99	-1.6	-22.6	-0.8%
<i>JJA 1998–MJJ 2000</i>	1999/00	-1.6	213.0	7.4%
SON 2000–JFM 2001	2000/01	-0.7	-96.2	-3.2%
ASO 2007–AMJ 2008	2007/08	-1.4	97.8	2.7%

Sources: United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), International Cocoa Organization (ICCO)

**FIGURE 9**  
**CHANGE IN GLOBAL COCOA PRODUCTION AND ENSO EVENTS**  
**PERIOD: 1949/50 – 2007/08**  
**(CONTINGENCY TABLE)**

<i>Weather condition</i>	El Niño	La Niña	Normal	Total
<i>Change in cocoa production</i>				
Negative	17	5	5	27
Positive	1	13	18	32
Total	18	18	23	59

Phi coefficient (*EL NIÑO*) = -0.72

Phi coefficient (*LA NIÑA*) = -0.07

**FIGURE 10**  
**ESTIMATED IMPACT OF EL NIÑO / LA NIÑA EVENTS ON COCOA PRODUCTION**

	La Niña	El Niño
<b>World</b>	-	<b>-2.43%</b> ***
<b>Africa</b>	-	<b>-1.44%</b> ***
Cameroon	-	-
Cote d'Ivoire	-	-2.03% ***
Ghana	-	-1.72% ***
Nigeria	-	-1.15% *
<b>Asia</b>	-	-
Indonesia	-	-2.39% ***
Malaysia	-	-
Papua New Guinea	1.68% ***	-
<b>Americas</b>	-	<b>-1.14%</b> ***
Dominica Republic	-	-
Brazil	-	-
Ecuador	-	-6.16% ***

- not significant impact

\*\*\* at 1% significant

\* at 10% significant

## REFERENCES

- Adams R. M., Chen C. C., McCarl B. A., Weiher R. F. (1999), "The economic consequences of ENSO events for agriculture", *Journal of Climate Research*, Vol. 13: 165–172
- Allan R, Lindesay J. and Parker D. (1996), "El Niño Southern Oscillation & Climatic Variability", *CSIRO Publishing*
- Bell, G. (2009), "Teleconnections", Climate Prediction Center (CPC) of the National Oceanic and Atmospheric Administration (NOAA)
- Bergeron N. and Sedjo R. (1999), "The Impact of El Niño on Northeastern Forests: A Case Study on Maple Syrup Production", *Resources For the Future Discussion Paper*, NO. 99-43
- Brunner A. (2000), "El Niño and world primary commodity prices: warm water or hot air", *International Monetary Fund Working Paper*, No. 00/203
- Dalton M. G. (2000), "El Niño, Expectations, and Fishing Effort in Monterey Bay, California", *Journal of Environmental Economics and Management* 42, 336–359
- ICCO (1997), "El Niño and cocoa production: an exploration of the influence of El Niño on world cocoa production. A presentation by the ICCO secretariat", *Cocoa Newsletter*, London: International Cocoa Organization, No.15
- IRI (2009), "El Niño teleconnections in Africa, Latin America and Caribbean, and Asia Pacific: Overview of current socio-economics and enhanced odds of anomalous seasonal precipitation", International Research Institute for Climate and Society Earth Institute, Columbia University
- McPhaden M.J. (2004), "Evolution of the 2002/03 El Niño", *Bulletin of the American Meteorological Society*, 85, 677-695
- NOAA (1999), "Improving El Niño forecasting: the potential economic benefits", National Oceanic and Atmospheric Administration, Office of Policy and Strategic Planning
- NOAA (2010), charts and data, <http://ftp.ncdc.noaa.gov/>
- Oldenborgh G. J. V. and Burgers G. (2005), "Searching for decadal variations in ENSO precipitation teleconnections", *Geophysical Research Letters*, Vol. 32, L15701, 5 PP
- Trzaska S., Fauchereau N., Pocard I., Camberlin P., Richard Y. and Pocard I. (2002), "Stability of the relationship between regional rainfall in Africa and ENSO", Centre de Recherches de Climatologie, CNRS/Université de Bourgogne