The Moroccan Association of Agricultural Economics (AMAECO)

in partnership with

International Association of Agricultural Economics (IAAE) **&** **United Nations University-World Institute for Development Economics Research (UNU WIDER)**

Climatic constraints play a predominant role in the performance of national agricultures and their capacity to support economic growth and assure food security for the population. With the climate changes and projected inter and intra annual fluctuations, management of the agricultural sector takes a particular dimension including management of risks inherent in the sector and searching for sustainable growth for the sector. Agricultural policies must permit a continual adaption of the processes of agricultural production and a reduction of negative effects of climate change in order to assure food security for the population.

In the face of climate change, the adaptation strategies can generate important development opportunities. Also, governments have need for pertinent evaluations of the impacts of climate change.

Considering the importance of this problem; to permit an exchange of ideas among professional staff, researchers, and specialists in the domain of development; to contribute to a richer understanding of methods and analytical tools ; and to contribute to better preparation of decision making in this domain – the Moroccan Association of Agricultural Economics (AMAEco) in collaboration with the International Association of Agricultural Economics (IAAE) and the World Institute For Development Economics Research of the United Nations University (UNU-WIDER) are organizing an international conference 6-7 December in Rabat, Morocco under the theme:

« Impacts of climate change on agriculture »

Rabat, Morocco December 6-7, 2011

The principal themes proposed are the following::

1. Analysis of the impacts of climate change on agriculture: simulations and projections
2. **Climate change and sustainability of agricultural production systems**
3. **Adaption strategies for agriculture in the face of climate change: systems of production, risks in agriculture, and policies for food security**
4. **Water management in the context of climate change**

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EFFECTS OF CLIMATE CHANGE ON COCOA PRODUCTION IN ONDO STATE, NIGERIA

BY

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ABSTRACT

The paper examined the effects of climate change on cocoa production in Ondo State, Nigeria. When talking about climate change and its effects, it is important to make adjustments and interventions in order to manage the losses or take advantages of opportunities presented by it. These adjustments or interventions are known as adaptation (IPCC, 2001).

Cocoa has been the second largest foreign exchange earner after crude oil and has also contributed significantly to infrastructural development in the country. Given this importance, one would expect it to be produced on a large scale and its production should be on the increase to boost the nation's foreign exchange earnings. But despite the nation's commitment to increase its production, it is still being faced with the problems of climate change which cannot be controlled by man. It is because of this that a study to determine the effects of climatic change on cocoa production and how farmers are able to adapt to the changing climatic conditions is being carried out.

The study made use of primary and secondary data. Primary data were collected through personal interview and administration of questionnaire on ninety (90) randomly selected cocoa farming households in the study area. Descriptive Statistics and Multiple Regression were the analytical tools.

The paper revealed among others that: the major climatic factors affecting cocoa production are rainfall and sunshine as attested to by 65.6% 0f the respondents. Majority of the respondents (76. 7%) are aware of climate change with high rainfall as the most noticeable climate change as attested to by 34.4 %of the respondents. The modal effect of climate change is high incidence of diseases outbreak as attested to by 20% of the respondents. The most commonly used adaptation strategy is a combination of diversification, modifying length of growing period, and changing planting dates as attested to by 16.7% of the respondents. The coefficient of determination, R^2 value shows that 45.1% of the variation in the yield of cocoa is explained by

the independent variables. The unexplained 54. 9% variations are due to the non- inclusion of other relatively important variables that cannot be measured in the regression equation

The major conclusion that of the paper is that: the level of awareness of climate change among cocoa farmers is high. The paper recommended among others that more awareness about climate change should be created among cocoa farmers through Public- Private Partnership.

INTRODUCTION

Cocoa as a major cash crop in Nigeria has contributed immensely to Nigeria's Economy for instance it has since being an important foreign exchange earner remaining the second largest foreign exchange earner after crude oil (Central Bank of Nigeria, 1998).

The crop has contributed greatly to infrastructural development in Nigeria and has imparted positively the lives of those who work and live in the cocoa belt which Ondo state belongs (Oluyole and Sanusi,2005).

Cocoa has also contributed immensely to the development of agro- based industries in Nigeria. (Olayide and Falusi, 1975). For instance between 1964 and 1975, a number of cocoa processing plants were established, for example Cocoa Industries Limited, large cocoa processing plants at Ede in Osun state and Ile-Oluji in Ondo state.

The spread of cocoa has also led to changes in the pre-existing pattern of labor employment in Nigeria. The increasing demand for labor in the cocoa belt area contributed to the development of different patterns of labor migration. The flow of labor seeking employment gradually turned to the cocoa belt and the cocoa farmers were able to find methods of employing and rewarding laborers for their seasonal needs (Oseni, 2010).

It is a source of income and savings to many small-scale farmers and the industry supports various categories of workers, such as produce buyers, cooperative societies and their workers, workers in the agro-chemical industry and the cocoa exporters and transporters (Sanusi, 1988).

The cultivation of cocoa has had some modifying effects on the traditional land tenure system. Since under the customary system of land tenure, the right of the individuals over the trees planted by them is recognized, the cultivation of coco means an indefinite interest on the

part of the producer in a particular plot of land. It also means an abrogation of shifting cultivation which is a feature of the customary system (Oseni, 2010).

The main producing states are Ondo, Ekiti, Oyo, Osun , Ogun, Delta, Edo, Kwara, Kogi, Abia, Taraba, Cross Rivers, Akwa-Ibom and Adamawa(Oluyole,2010). According to Oyekale et al (2009), 50 % of the total quantity of cocoa produced for export or utilized locally per annum comes from Ondo State.

Climate is the most important factor that influences cocoa production. Cocoa is highly sensitive to rainfall, sunshine and temperature. Climate is characterized by the stability over a long period of meteorological characteristics specific to a given geographic environment. It is the state of the atmosphere created by weather events over a period of time. A change in the state of the atmosphere created by weather events over a period of time is known as climate change. Climate change is caused by the accumulation of the green house gases in the lower atmosphere. A green house gas is one that traps heat in the earth's atmosphere (Strasburg, 2009). The most abundant green house gases carbon (iv) oxide, methane, nitrogen (i) oxide and chlorofluorocarbons (Intergovernmental Panel on Climate Change, 2007). However the concentrations of these gases are increasing mainly due to human activities such as the combustion of fossil fuels and deforestation.

When talking about climate change and its effects, it is important to make adjustments and interventions in order to manage the losses or take advantages of opportunities presented by it. These adjustments or interventions are known as adaptation (IPCC, 2001).

Cocoa has been the second largest foreign exchange earner after crude oil and has also contributed significantly to infrastructural development in the country. Given this importance, one would expect it to be produced on a large scale and its production should be on the increase to boost the nation's foreign exchange earnings. But despite the nation's commitment to increase its production, it is still being faced with the problems of climate change which cannot be controlled by man. It is because of this that a study to determine the effects of climatic change on cocoa production and how farmers are able to adapt to the changing climatic conditions is being carried out.

The major objective of the study is to examine the effects of climate change on cocoa production in Ondo State

The specific objectives are to:

1. Examine the socio-economic characteristics of cocoa farming household.

2. Determine the perceived effects of climatic variables (rainfall, temperature and sunshine) on cocoa yield.

3. Determine the adaptation strategies adopted by cocoa farmers to changes in climatic patterns to guide against crop failure and yield losses

4. Determine the influence of other variables apart from climatic variables on the yield of cocoa

5. Determine the level of awareness of climate change by cocoa farming households in the study area.

Cocoa being a major cash crop in Nigeria, a major contributor to Nigeria's economy and given the other important roles that it plays in the economy, a study on how its production can be increased and sustained is relevant.

The study is important because recommendations made based on findings could help boost its production in the state and the same could be applied by other producing states thereby boosting its production in the nation at large.

2.0 LITERATURE REVIEW

Climate change is a change in the average weather that a region experiences. Average weather includes all the features associated with weather such as temperature, rainfall and wind patterns. Climate change is caused by the accumulation of green house gases in the lower atmosphere.

However the concentration of these gases is increasing mainly due to human activities such as combustion of fossil fuels(releases carbon(iv)oxide) and deforestation which adds about 1.6 million metric tons of carbon(iv)oxide in the atmosphere annually(Botkin and Keller,2000).

This is not to say that climate change is caused only by man's activities, there are other causes created by nature such as release of methane gas which is a green house gas from wetlands (Strasburg, 2009). Another one is that the earth goes through a cycle of climatic changes, which usually lasts about 40,000 years (Wikipedia, 2007). Climate change has impact on health with regards to natural disasters, poor water quality and quantity, problem of food security, air pollution, social dislocation and infectious diseases (Answers.com, 2011).

Climate change is the primary determinant of agricultural productivity. It is expected to influence crop and livestock production, hydrological balances and other components of agricultural systems. Crop and livestock yields are directly affected by changes in climatic factors such as temperature, precipitation and extreme events like drought, floods and windstorm (Adams and Carl, 1999)

Cocoa production is highly sensitive to weather variables from length and intensity of sunshine to rainfall and water application and temperature (Anim-Kwapong, 2008). It is highly susceptible to drought and pattern of cropping of cocoa is related to rainfall distribution. The death of cocoa seedling is encouraged by prolonged drought and its planting is highly determined by the start of the rain.

Cocoa performs better under calm conditions and persistent moderate wind can cause a severe damage to yield. It reacts badly to any incidence of extreme weather (Wood, 1985). Climate change also alters the stages of rates of development of cocoa pests and pathogens

modify host pathogen or pest interaction which will impact on the socio-economic variables such as farm income, farm level decision making, and marketability and farmers livelihoods.

The three major climatic factors that affect cocoa production are rainfall, temperature and sunlight. They affect the three phases of cocoa production ranging from seedling phase, establishment phase to processing phase (Oyekale, 2009).

1. Rainfall.

It is the most important climatic variable that affects cocoa production. Minimal but sustained water throughout the year allows for better yield. Too much of rainfall leads to the spread of fungal diseases (black pod disease which is very contagious and reduce yield). Too little rainfall (drought) results in lower yield by reducing bean size and an increase in the level of capsid infestation (Oluyole, 2010).

Rainfall influences majorly the establishment phase because the planting of cocoa is dependent on rainfall. Too much of rainfall also slows down drying and processing of the cocoa seeds thereby reducing the value of the beans and an increase in the cost of processing (Oyekale, 2009).

2. Temperature.

The higher the temperature, the higher the yield. The temperature should be a maximum of 32 ºC (Obatolu et al , 2003).

3. Sunlight.

It is important to speed up photosynthetic rate, produces energy for warming the soil, plants and the air (Oluyole, 2010). However too much of this favors the buildup of capsids (a disease of cocoa). Sunlight is very important during the processing stage as it ensures proper drying of the coca beans which enhances the value of the beans (Oyekale, 2009).They are most active when moisture deficit is severe in other words they are caused by drought (Ajewole, 2010).

The assessment of the coping strategies or adaptation options adopted by cocoa farmers to sustain the adverse effect imposed on cocoa production by climate change is important to formulate policies that enhances it as a tool for managing a variety of risks associated with climate change and it also provides information that increases the capacity of farmers to survive external shocks and changes (Oyekale, 2009).

3.0 METHODOLOGY

The study was carried out in Ondo state of Nigeria.Ondo state is bounded in the west by Osun and Ogun states, in the north by Ekiti and Kogi states, in the east by Edo and Delta States and in the South by the Atlantic Ocean.

Ondo state was created on the 3rd of February, 1976 from the former western state. Akure is its capital. It has 18 local government areas with the major ones being Akoko, Akure, Okitipupa, Ondo and Owo local government areas.

The majority of the inhabitants live in the urban areas. It has a population of 3,812,793(National Population Commission, 2006). The state is characterized by heavy rainfall with climate following the usual tropical pattern. The rainy season starts from March and rounds up around October while dry season is from November to February/march. Food crops such as cocoyam, tomato, maize, plantain and cash crops such as cocoa and timber are cultivated in the state (Oseni, 2010).

This study was carried out in Idanre and Ondo East local government areas of Ondo state. Idanre local government was chosen because it has been the highest producer of cocoa in Ondo state in the last four years (Cocoa Grading Figures, 2007-2010) and Ondo East was also chosen because majority of the farmers there are engaged in cocoa production.

The study made use of primary and secondary data. Primary data were collected through personal interview and administration of questionnaire on cocoa farming households in the study area. Multi-stage sampling technique was used to select the farmers that were interviewed and the interviews were conducted privately to avoid duplication of ideas and unnecessary influence of one farmer answer on the other. On the whole, ninety (90) respondents were interviewed at an average of 45 respondents per local government area. The Meteorology Department of Agricultural Development Project (ADP) was visited to collect information on climate change.

Descriptive Statistics and Multiple Regression were the analytical tools used. . The descriptive statistics was used to analyze the socio-economic characteristics of cocoa farming households as well as the magnitude of the climatic variables; rainfall, sunshine and temperature. Multiple regression analysis was used to estimate the effects of the climatic variables on cocoa production.

The implicit form of the regression equation is stated as:

$Y = f(X1, X2, X3, e)$

Where Y= Output of cocoa (metric tons)

X1 = Mean Annual Rainfall (Millimeter)

X2 = Mean Annual Temperature (Degree Centigrade)

X3 = Mean Annual sunshine (Hours)

e = Error Term. Three functional forms will be fitted:

- Linear Function

  $Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + e$

- Semi- Log Function

  $Y = b_0 + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + e$

- Cobb – Douglas

  $\text{Log } Y = b_0 + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3$

The following criteria were used to choose the lead equation:

1. The magnitude of R^2 – that is the functional form that has the highest R^2

2. The significance of multiple regression coefficients with respect to t-ratios and standard errors of estimates.

3. The correct signs of the parameters

4.0. RESULTS AND DISCUSSION

As shown in Table 1, majority of the respondents (72.2%) are male and are married (81.1%) and with a family size of between six and ten years (6-10years) as attested by 62.2% of the respondents. The implication of this is that the respondents are assumed to be responsible and could take crucial decisions that affect their cocoa production enterprise jointly with the spouses. The modal age of the farmers is above sixty (60) years as attested to by 44.4% of the respondents and they also had considerable experience in cocoa farming with about 35,6% of them having over thirty(30) years experience in cocoa farming. Majority of the respondents (40%) had no formal education. The implication of this is that they may not be receptive to new innovations on climate change.

Table 2 revealed that the major climatic factors affecting cocoa production are rainfall and sunshine as attested to by 65.6% 0f the respondents. As contained in Table 3, majority of the respondents (76. 7%) are aware of climate change with high rainfall as the most noticeable climate change as attested to by 34.4 %of the respondents. The most critical climatic variable is rainfall as attested to by 57. 8% of the respondents. The modal effect of climate change is high incidence of diseases and pests infestation as attested to by 20% of the respondents. The most commonly used adaptation strategy is Diversification, modifying length of growing period, and changing planting dates as attested to by 16.7% of the respondents.

Table 1: Socio-economic characteristics of the respondents

Sex	**Frequency**	**Percentage**
Male	65	72.2
Female	25	27.8
Total	90	100.0
Marital Status	**Frequency**	**Percentage**
Married	73	81.1
Single	5	5.6
Divorced	2	2.2
Widowed	10	11.1
Total	90	100.0
Family Size	**Frequency**	**Percentage**
1 to 5	23	25.6
6 to 10	56	62.2
Above 10	11	12.2
Total	90	100.0
Age range in years	**Frequency**	**Percentage**
30-40	14	15.6
41-50	14	15.6
51-60	22	24.4
Above 60years	40	44.4
Total	90	100.0
Educational qualification	**Frequency**	**Percentage**
None	36	40.0

Primary school	12	13.3
Modern school	16	17.8
Secondary school	19	21.1
University graduate	7	7.8
Total	90	100.0
Farming experience	**Frequency**	**Percentage**
1-10years	5	5.6
11-20years	30	33.3
21-30years	23	25.6
over 30 years	32	35.6
Total	90	100.0

Source: Field survey, 2011

Table 2: Farming activities of the respondents

Farm size in acres	**Frequency**	**Percentage**
Less than 1 Acre	19	19
1 to 5 Acres	50	50
6 to 10 Acres	17	17
Above 10 Acres	4	4
Total	90	90
Varieties of cocoa planted	**Frequency**	**Percentage**
Agric	69	76.7
Local	7	7.8
Both	14	15.6
Total	90	100.0
Location of the farm in the same place	**Frequency**	**Percentage**
Yes	43	47.8
No	47	52.2
Total	90	100.0
Method of land acquisition	**Frequency**	**Percentage**
Purchase	35	38.9
Leasing	5	5.6
Inheritance	17	18.9

Direct purchase and leasing	6	6.7
Direct purchase and inheritance	27	30.0
Total	90	100.0
Source of finance	**Frequency**	**Percentage**
Moneylenders	6	6.7
Personal savings	76	84.4
Cooperatives	2	2.2
Merchant lenders	1	1.1
Money lenders and personal savings	3	3.3
Money lenders and commercial banks	1	1.1
Personal savings and merchant lenders	1	1.1
Total	90	100.0
Type of labour used on the farm	**Frequency**	**Percentage**
Family labour	7	7.8
Hired labour	65	72.2
Both	18	20.0
Total	90	100.0
Mode of payment of labour	**Frequency**	**Percentage**
Daily	8	8.9
Weekly	2	2.2
Monthly	1	1.1
Yearly/sharecropper	79	87.8
Total	90	100.0
Climatic factors that affects cocoa	**Frequency**	**Percentage**
Rainfall	19	21.1
Sunshine	1	1.1
All	10	11.1
Rainfall and sunshine	59	65.6
Rainfall and temperature	1	1.1
Total	90	100.0
Average annual yield of cocoa	**Frequency**	**Percentage**
Less than 1 ton	35	38.9
1-5 tons	47	52.2
Above 5 tons	8	8.9
Total	90	100.0

Source: Field survey, 2011

Table 3: Climate change activities

Awareness of climate change	**Frequency**	**Percentage**
Yes	69	76.7
No	21	23.3
Total	90	100.0
Type of climate experienced	**Frequency**	**Percentage**
High rainfall	31	34.4
Low rainfall	12	13.3
Unfavourable sunlight	2	2.2
Unpredictable weather	23	25.6
Low rainfall and unfavourable sunlight	1	1.1
No response	21	23.3
Total	90	100
Year climate change was noticed	**Frequency**	**Percentage**
Last year(2010)	18	20.0
Last 2 years(2009)	20	22.2
Last 3 years(2008)	14	15.6
Last 4 years(2007)	9	10.0
Last 5 years(2006 and below	8	8.9
No response	21	23.3
Total	90	100.0
The most critical climatic factor	**Frequency**	**Percentage**
Rainfall	52	57.8
Sunshine	5	5.6
All	1	1.1
Rainfall and sunshine	11	12.2
None	21	23.3
Total	90	100
Effects of climatic change	**Frequency**	**Percentage**
Reduced weight	4	4.4
Disease	18	20.0
Pest	3	3.3
Reduced weight and disease	17	18.9
Reduced weight and pest	3	3.3
Pests and diseases	13	14.4
All	11	12.2
No response	21	23.3
Total	90	100.0
Pest and disease affecting cocoa	**Frequency**	**Percentage**

Capsid pest	6	6.7
Blackpod disease	34	37.8
Both	27	30.0
Others	2	2.2
No response	21	23.3
Total	90	100
Source of water	**Frequency**	**Percentage**
Rainfall	73	81.1
Streams	12	13.3
Wells	3	3.3
13	2	2.2
Total	90	100
Number of times spraying was carried out	**Frequency**	**Percentage**
4 to 7 times	60	66.7
Depends on rainfall	23	25.6
No response	7	7.8
Total	90	100.0
Conditions under which spraying was carried out	**Frequency**	**Percentage**
Cloudy	1	1.1
Sunny	7	7.8
Any condition but rainy	81	90.0
Others	1	1.1
Total	90	100.0
Adaptation and or coping strategies	**Frequency**	**Percentage**
Diversification	5	5.6
Changing planting dates	5	5.6
Changing harvesting dates	9	10.0
Constant spraying	1	1.1
Diversification and changing harvesting dates	10	11.1
Diversification and constant replacing	4	4.4
Changing harvesting date and constant spraying	10	11.1
Diversification, modifying length of growing period, and changing planting dates	22	16.7
Diversification, modifying length of growing period, changing planting dates, changing harvesting dates.	1	1.1
Diversification, changing	2	2.2

harvesting dates ,constant spraying		
No response	21	23.3
Total	90	100.0

Factors influencing the adoption of coping strategy	**Frequency**	**Percentage**
Fund	12	13.3
Experience	12	13.3
Awareness/enlightment	10	11.1
None	3	3.1
Fund and experience	12	13.3
Fund and awareness	9	10.0
Experience and awareness	8	6.7
Experience, fund and awareness	1	1
No response	21	23.3
Total	90	100

Source: Field Survey, 2011

Table 4: Regression Results

Variable	Parameters	Linear	Semi-log	Cobb-Douglas
Constant		11077.872 (100491.580)	-745479.043 (631047.980)	-0.653 (6.053)
Average Sunshine (hours)	X_1	-4679.917 (6161.002)	92672.365 (147607.200)	0.460 (1.414)

Average rainfall(millimeters)	X_2	2.012 (21.754)	145467.696 (129098.902)	1.091 (1.237)
Average Temperature(Centigrade)	X_3	2646 (3253.53)	18813791 (182216.280)	1.084 (1.749)
R^2		0.419	0.451	0.441

Source: Computer Printout of Field Data, 2011

Figures in parenthesis are the standard errors of the coefficients.

The regression result of the lead equation of the semi-log functional form is as presented below:

$Y= -745479.043+ 92672.365\log X_1 + 145467.696\log X_2 +188137.137\log X_3$

(631047.98) (147607.20) (129098.902) (182216, 280)

$R^2= 45.1$

The coefficient of determination, R^2 value shows that 45.1% of the variation in the yield of cocoa is explained by the independent variables. The unexplained 54. 9% variations are due to the non-inclusion of other relatively important variables that cannot be measured in the regression equation.

5.0. CONCLUSION AND RECOMMENDATIONS

The major conclusion that could be drawn from the paper is that: the level of awareness of climate change among cocoa farmers is high. The perceived effects of climate change on cocoa production in order of importance are: diseases, reduced weight of cocoa pod and disease, incidences of pests and disease outbreak. The paper recommended among others that more awareness on climate change should be created among cocoa farmers through Public- Private Partnership on the effects, coping and adaptation strategies of climate change.

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