GLOBAL JOURNAL OF BIOLOGY, AGRICULTURE & HEALTH SCIENCES
(**Published By**: *Global Institute for Research & Education*)
www.gifre.org

EFFCTS OF AGROCLIMATIC CHANGE ON CASSAVA BASED CROP MIXTURE SYSTEM IN CRUDE OIL PRODUCING AREAS OF IMO STATE, NIGERIA

Nwosu, C.S.[1] & C.J. Arene[2]

[1]Department of Agricultural Economics and Extension,
Imo State University, Owerri, Nigeria.
[2]Department of Agricultural Economics,
University of Nigeria, Nsukka, Nigeria.

Abstract

The study examined the effects of agro climatic change induced by crude oil exploitation activities in Imo State, Nigeria. The study revealed dissimilarities in socio-economic characteristics of cassava based crop mixture (CBCM) farmers in crude oil and non-crude oil producing areas. Output levels of the food crop components in the CBCM system in non-crude oil producing area were significantly higher than those of the crude oil producing area. There were observed significant negative and positive relationships between output of the based crop (cassava) of the crop mixture system and some of the considered socio-economic factors in both areas. Based on the findings the oil companies operating in the area should change their operational procedures to reduce environmental pollution from oil exploration. Indigenous adaptation measures should also be identified to ameliorate CBCM farmers' socio- economic worsening situations.

Keywords: Agro-climate, cassava-based-crop-mixture, crude oil, and socio-economic characteristics.

1. Introduction

Climate is the most significant factor that determines crop productivity hence constitutes a complex of inter-related variables. It is a dynamic phenomenon that is always changing (CRA, 2007). IPCC (2007) defines climate change as any change in climate over times whether due to natural variability or as a result of human activity. This definition differs from that of the United Nation Framework on Climate Change (UNFCC) that attributes climate change to direct or indirect human activity that alters the composite one of the global atmosphere (IPCC, 1996). Climate change may be limited to a specific area or may occur across the whole earth. However, the risks associated with climate change lie in the interaction of several systems with several variables collectively considered (Sombroek, 1990). Significant change in temperature and precipitation can make a primary crop no longer feasible in a given area (CRA, 2007).

Human activities especially crude oil exploitation adversely induces changes in the agro climatic conditions of an area to the detriment of food crop production (Nwosu *et al*, 2008). Crude oil is a naturally occurring liquid hydrocarbon of organic origin, dark in colour and occupying the interstices of permeable rocks such as limestone seal in below the earth's crust (Akwiwu *et al*, 2002). The long process of exploring the oil, prospecting, drilling, refining and transportation consist crude oil exploitation (Njoku, 1995). Gas flaring, a component crude oil exploitation activity, has negatively changed the prevailing agro climate of the crude oil producing areas in terms of causing very high temperature and acid rain (Nwosu *et al*, 2008). These have been adversely affected the arable crop productivity in the crude oil producing communities (Ukaegbu and Okeke, 1987; Olemeforo, 2000; Pernar et al, 2006 and Alam *et al*, 2010) and the socio-economic factors of arable crop farmers in the area.

Crude oil discovery in Imo state necessitated the presence of oil exploitation companies in Ohaji/Egbema and Oguta Local Government Areas (LGAs). These LGAs are among the major arable food crops producing areas of the state. Again, production arable food crops in Imo state is achieved through two main based crop mixture systems namely cassava based crop mixture (CBCM) and yam based crop mixture(YBCM) systems (IMOADP, 2000). Cassava based crop mixture (CBCM) is one of the two common crop mixture systems practised in crude oil and non- crude oil producing areas of Imo state, Nigeria. CBCM is composed of cassava, maize and melon with cassava as the based crop. The crop mixture is a viable strategy for spreading the risks of crop failure and labour demands for critical operations of sowing, weeding and harvesting (Eze *et al*, 2009). However, in the 1980s, the Ashland Oil, Nigeria, commissioned a study on the impact of gas flaring at Izombe flow station in Imo state on the growth potential, productivity and yield of arable food crops cultivated within various distances and directions of the flare (Ukaegbu and Okeke, 1987). The results showed that 100 percent loss in yield was recorded for crops, 200 metres away; 45 percent loss for those 600 metres away and 10 percent loss in yield for crops cultivated about 1000 metres away from flare site. These results were attributed to agro climatic change in terms of very high temperature and acid rain predicated by gas flaring. A gap in knowledge on the socio-economic effects of this agro climatic change on CBCM farmers has being observed. Hence the assessed of the socio-economic effects of agro climatic change on CBCM farmers in crude oil producing communities and using non-crude oil producing communities that share similar micro agro ecological zone as comparative yard sticks.

2. Methodology

The study was carried out in Imo state in the southeast of Nigeria. The state was purposely chosen because it is one of the oil producing state in the Niger Delta Region with agro climatic change in terms of very high temperature and acid rain predicated by gas flaring. In the state there are crude oil and non-crude oil producing communities. The main food crops grown in state are cassava, yam, maize, rice and cocoyam; while the major vegetables are melon okra, fluted pumpkin and waterleaf. On small-holder plots, these crops are usually grown in mixtures through two main based crop mixture systems – cassava based crop mixture (CBCM) and yam based crop mixture (YBCM) systems. Cassava based crop mixture composed of cassava, maize and melon with cassava as lead or based crop.

The study was concentrated in the two crude oil producing LGAs, namely Ohaji/Egbema and Oguta LGAs and two other non-crude oil producing LGAs of the state that share common micro agro ecological boundaries with the two crude oil producing LGAs of the state – Owerri- West and Ngor Okpala. Five communities were selected from each of the four purposely selected LGAs, making 20 communities in all. Stratified random sampling was adopted in selection of respondents drawn from CBCM farmers from communities in crude oil and non-crude oil producing LGAs. Five respondents were selected from each of the 20 communities given a total of 100 CBCM farmers. The sample frames from which the respondents were randomly selected were lists of names of CBCM contact farmers of Imo State Agricultural Development Programme from crude oil and non-crude oil producing communities of the purposively selected four LGAs.

Cross sectional data were collected for the study with the aid of detailed questionnaire administered to the selected CBCM farmers in the crude oil and non-crude oil producing areas. The socio-economic characteristics and output levels of CBCM farmers in the crude oil non-crude oil producing areas were analyzed using frequency distribution, mean, tables and percentages. The difference output level in the two areas was tested using student t-test. While the relationship between output of the based food crop component (cassava) of the CBCM in crude oil and non-crude producing areas and socio-economic characteristics of their CBCM farmers was achieved using multiple regression analysis.

The implicit multiple regression model is stated thus: $Y= f(X_1,X_2,X_3,X_4,X_5,X_6,\ldots e)$.

Where Y= output (kg),
X_1= age of CBCM farmers (years),
X_2= sex (male and Female) (dummy),
X_3= marital status (dummy),
X_4= Farm size (ha),
X_5= household size (number of persons),
X_6= level of CBCM farmer's education (years),
X_7= farming status (dummy),
X_8= CBCM farming experience (years),
X_9= income level of CBCM farmer (₦), and
e= stochastic error term.

The t-values of the multiple regression analysis results were used to test the level of significance of the relationship between the output of the based food crop component (cassava) of CBCM in crude oil and non-crude oil producing areas and socio-economic characteristics of their CBCM farmers. This was further tested by test of equality between coefficients using Chow test, which is F-ratio given as:

$$F^* = \frac{[\sum e_p^2 - (\sum e_1^2 + \sum e_2^2)] / K}{(\sum e_1^2 + \sum e_2^2) / (n_1 + n_2 - 2k)}$$

Where: $\sum e_p^2$ = sum of pooled unexplained variations from multiple regression of pooled observations from both crude oil and non-crude oil producing areas,
$\sum e_1^2$ = sum of residual variations from multiple regression of observation from crude oil producing areas,
$\sum e_2^2$ = sum of residual variations from multiple regression of observations from non-crude oil producing areas,
n_1 and n_2 = sample sizes CBCM farmers from crude oil and non-crude oil producing areas, and
k = number of coefficients of the estimated variables including the intercept (Koutsoyiannis, 1979).

3. Results and Discussion

3.1 *Socio-economic Characteristics of Cassava Based Crop Mixture (CBCM) Farmers in Crude Oil and Non-crude Oil Producing Areas*

Table 1 shows the socio-economic characteristics of CBCM farmers in crude oil and non-crude oil producing areas in terms of gender, age, marital status, educational status, household size, farming experience and household income level. Most CBCM farmers in crude oil producing areas were predominantly males (82%) due to reduction in farm land availability predicated by crude oil exploitation. In non-crude oil producing area gender percentage distribution of CBCM farmers slightly skewed towards the female farmers (54%). Traditionally, women are cassava producers. This result might be due to economic pressure and greater awareness arising from education which is increasingly breaking down the traditional gender farming pattern of female farmers being mostly involved in cassava production.

Age distribution of CBCM farmers in crude oil producing area was less active age group with mean age of 51.1years. This shows that farmers in this area were aging which could be attributed to youth abandonment of farming for highly paying oil company seismic jobs and white collar jobs. This result is in agreement with Akwiwu (2002), Olowu *et al* (1990) and Aju (1999) findings. In non-crude oil producing area the age of CBCM farmers cluster within the relatively active age bracket of age 36 to 55 years with mean age of 47.1 years. This age distribution pattern of CBCM farmers in non-crude oil producing area might be due to youth participation in agricultural production and elderly people's withdrawal from active participation as reported by Mejah (1991). Majority of CBCM farmers in crude oil (82%) and non crude oil (84%) producing area were married. Similar results in both area suggested that CBCM farmers who were married invariably had large household size that supplied the highly needed family labour in food crop production.

The study observed similar percentage distribution according to educational status of CBCM farmers in crude oil and non-crude oil production areas. These results might be attributed to high literacy level of the people in the state. The CBCM farmers in crude oil and non-crude oil producing areas were grouped into full time, mixed and part time CBCM farmers. Based on the classification 72% and 50% of CBCM farmers in crude oil and non-crude oil producing areas, respectively were full time farmers. The dissimilarity in the percentage distribution trend might be connected with

Table 1: Socio-economic Characteristics of Cassava Based Crop Mixture (CBCM) Farm in Crude Oil and Non-Crude Oil Producing Areas]

Character	CBCM Farmers in Crude-Oil Producing Area		CBCM Famers in Non-Crude Oil Producing Area	
	Frequency	%	Frequency	%
Gender				
Male	41	82	23	46
Female	9	0	27	54
Age (in years)				
< 25	0	0	3	6
26 – 35	0	0	2	4
36 – 45	7	14	15	40
46 – 55	33	66	23	46
> 55	10	20	7	14
Mean Age ($\bar{X}$)	51.1 years		47.1 years	
Marital Status				
Single	0	0	3	6
Married	41	82	42	84
Widowed	9	18	5	10
Educational Status				
No formal Education	7	14	5	10
Primary Education	15	30	14	28
Secondary Education	18	36	13	28
Higher Education	10	20	18	34
Farming Status				
Full-time	36	72	25	50
Mixed farmer	0	0	10	20
Part-time	14	28	15	30
Household Size (No passion)				
1 – 5	8	16	26	52
6 – 10	37	74	21	42
11 – 15	3	6	2	4
16 – 20	2	4	1	2
Mean ($\bar{X}$)	8 persons		6 persons	
Farm Size (ha)				
0.1 – 1.0	38	76	10	20
1.1 – 2.0	10	20	16	32
2.1 – 3.0	2	4	17	34
3.1 – 4.0	0	0	7	4
Mean ($\bar{X}$)	1.024ha		2.284ha	
Farming Experience (years)				
1 – 5	3	6	5	10
6 – 10	23	46	19	38
> 10	24	48	26	52
Household Income Level Per Cropping season				
< 50,000	23	46	2	4
50,000 – 110,000	8	16	13	26
110,000 – 170,000	7	14	20	40
170,500 – 230,000	7	14	10	20
230,500 – 290,000	3	6	3	6
> 290,000	2	4	5	10
Mean ($\bar{X}$)	₦103,940		₦152,240	

t–test for farm size difference in Mean: t – calculated = 8.21
t – tabulated at 1% level of probability = 2.37

the adverse effects of crude oil exploitation on crops output in crude oil producing areas. The prevailing situation demanded that only those who were full time farmers and has no other source of livelihood could farm in such vicinity.

The mean household sizes for CBCM farmers for crude oil and non-crude oil producing areas were eight and six persons, respectively. The high percentage of CBCM farmers in crude oil producing area having large household sizes explains the reason why farmers in the area still remain in farming business since large household sizes entails cheap farming labour that cushions effect of high labour and which the area is known for.

The mean farm sizes of CBCM farmers in crude oil and non- crude oil producing areas were 1.024ha and 2.284ha, respectively. Using student t-test at the 1% level of probability, the differences in means of CBCM farmers in crude oil and non-crude oil producing areas were highly significant with t-calculated (8.21) greater than t-tabulated (2.37) in favour of CBCM farmers in non-crude oil producing areas. The small farm sizes of CBCM farmers in crude oil producing area was due to steady decline in the availability of productive farm land resulting from activities of oil companies in the area. These activities include laying seismic pipes, digging of burrow pits, establishing of flaring sites and building of access roads and flow stations. Besides, some of the activities made the farmers less vulnerable to oil spillage, thus, a hitherto fertile land became unfertile and unproductive.

Majority of farmers in crude oil and non crude oil producing areas had more than six years food crop production experience. Farming experience is a key factor that affects farmers' productivity since experienced farmers are capable of combining factors of production efficiently to maximize output. Thus, it assumed that the longer the years of farming experience, the more efficient the farmer becomes (Nwaru, 1993).

The average household income for CBCM farmers in crude oil and non-crude oil producing areas were ₦103,940 and ₦157,240, respectively. The observed distinct variation in percentage distribution pattern of CBCM farmers by household income in crude oil and non-crude oil producing areas were attributed to low yields caused by the effects of crude oil exploitation activities. Farm income is dependent on yield and per unit price hence CBCM farmers in crude oil producing area had poor income level. The low crop yield in crude oil producing area was related to gas flaring by oil companies operating in the area that created adverse agro-climatic conditions prevalent in the area (Awobajo, 1993; NEST 1991; Ukegbu and Okeke, 1987; Alam *et al* 2010; and Pernar *et al*, 2006).

3.2 *Output levels of CBCM farmers*

The outputs of three major crops' components cassava based crop mixture for crude oil and non-crude oil producing areas are shown in table 2**.** The cassava based crop mixture is composed of cassava as the main crop in association with maize and melon. In the crude oil producing area, the outputs of cassava, maize and melon per hectare were 12,469kg, 1,741.896kg and 150.639kg respectively. While in non-crude oil producing area the output per hectare for cassava, maize and melon were 17,262.277kg and 257.454kg, respectively. These outputs were relatively higher in favour of non-crude oil producing area with cassava, maize and melon having differences of 4,792.550kg (27.76%), 735.381kg (29.69%) and 106.815kg (41.49%), respectively. The differences in cassava, maize and melon outputs were significant at 5% and 1% levels of probability, respectively. This agreed with *a prior* expectation that the levels of output of food crops in crude oil producing areas would be lower due to gas flaring and other effects of crude oil exploitation activities that adversely influence agro climatic conditions of the area (Okoli, 2006). Furthermore, these results on output levels of food crops in the crude oil producing area were in agreement with results on agronomic investigation of Ukaegbu and Okeke (1987).

Table 2: Output Levels of Cassava Based Crop Farmers in Crude and Non-Crude Oil Producing Areas

Cassava based Crop Mixture	Crude oil producing Communities Average Food Crop Output Kg/ha	Non-Crude Oil producing Communities Average Food Crop Output kg/ha	Output Difference	% Output Difference
Cassava	12,469.727	17,262.277	4,792.550 27.76	27.76
Maize	1,741.896	2,477.277	734.381 29.69	29.69
Melon	150.639	257.354	106.815 41.49	41.49

t-test:
CBCM
Cassava: t-calculated = 1.82; t-tabulated at 1% and 5% levels of probability = 2.37 and 1.66, respectively.
Maize: t-calculated = 4.54; t-tabulated at 5% and 1% levels of probability = 1.66 and 2.37, respectively.
Melon: t-calculated = 1.33; t-tabulated at 5% level of probability = 1.66

3.3 *Relationship between Outputs of Based Food Crop Component (cassava) of the Cassava Based Crop Mixture (CBCM) System in Crude Oil and Non-crude Oil Producing Areas and Socio-economic Characteristics of CBCM Farmers*

Cassava based crop mixture CBCM system consist of cassava, maize and melon components with cassava as the major component. The socio- economic variables were regressed on the output of based or lead crop component (cassava) in CBCM in both areas.

The linear and double-log functional forms were chosen as lead regression equations for the crude oil and non-crude oil producing areas, respectively. This is because they gave the best fit. The lead equations were:

Y_o=409.8239 – 47.8473 X_1 + 836.9970X_2 +364.9665X_3 + 904.9044X_4 – 151.4770X_5 – 114.0299X_6 – 9.8092X_7 + 103.2413X_8 + 0.0482X_9 for the crude oil producing area; and

Y_{no}=1.7785 + 0.1032LNX_1 – 0.0377LNX_2 + 0.0235LNX_3 + 0.4546LNX_4 – 0.0294LNX_5 + 0.1732LNX_6 – 0.0379LNX_7 + 0.0610LNX_8 + 0.5561LNX_9 for the non-crude oil producing area.

Tables 3 and 4 showed all the relevant parameter estimates. The regression lines for the cassava

Table 3: Regression Results for Cassava Component in CBCM in Crude Oil Producing Communities

Variables	Linear	Double-log	Semi-log	Exponential
Intercept	409.8239	-2.1252**	-34753.7263	7.7014***
	(0.15)	(-1.90)	(-1.42)	(6.49)
Age(X_1)	-47.8473	-0.3327	-2358.0749	0.0039
	(-1.51)	(-1.63)	(0.53)	(0.29)
Sex(X_2)	836.9970**	0.1272	566.9553	-0.1337
	(1.79)	(1.09)	(0.23)	(-0.67)
Marital status(X_3)	364.9665	0.0000	0.0000	0.1500
	(0.54)	(0.00)	(0.00)	(0.52)
Farm size(X_4)	904.9044**	0.1244	721.6426	0.1554
	(1.80)	(1.30)	(0.34)	(0.72)
Household size(X_5)	-151.4770	-0.0587	-14650.0606***	0.0167
	(-1.63)	(-0.53)	(-5.83)	(0.42)
Farmer's education(X_6)	-114.0299**	-0.2491**	-3578.9151	0.0071
	(-1.82)	(-1.94)	(-1.44)	(0.27)
Farming status(X_7)	-9.8092	0.0503	128.4959	0.0035
	(-0.14)	(0.44)	(0.05)	(0.12)
Farming experience(X_8)	103.2413	0.0136	4696.8044***	-0.0220
	(1.37)	(0.16)	(2.64)	(-0.69)
Farmer's income(X_9)	0.0482***	1.0657***	6762.4187***	0.000004***
	(31.14)	(19.12)	(5.76)	(5.57)
R^2	0.9875	0.9739	0.8728	0.7176
$\bar{R}^2$	0.9851	0.9688	0.8480	0.6625
F-ratio	351.62	107.43	20.59	11.29

( ) t-statistic computed; *** statistically significant at 1%; ** statistically significant at 5%

component in both areas gave coefficients of multiple determinations (R^2) of 0.9956 and 0.9859, respectively, which also implied that the nine considered socio-economic factors explained 99.56% and 98.59% of the variations in Y_o and Y_{no}, respectively.

The F-test results showed that the combined impact of the independent variables on the cassava output in both areas were significant. The F-ratios obtained in crude oil and non-crude oil producing areas were 107.43 and 178.42, respectively, which were greater than the theoretical value of 2.91 at the 1% level of probability.

In crude oil producing communities, the t-test showed that the considered socio-economic variables that had significant t-values at the 1% and 5% levels of probability were farmer's income and farm size, sex and farmer's education, respectively (Table 3). Age, marital status, household size, level of spouse's education, and food crop farming experience were insignificant at the 5% level of confidence (Table 3). In non-crude oil producing areas, farm size, farmer's education, food crop farming experience and farmer's income had significant t-values at the 1% level of confidence, while only age was significant at the 5% level of confidence (Table 4). Table 4 also showed that in non-crude oil producing areas, the t-values of sex, household size and level of spouse's education were not significant even at the 5% level of confidence.

Age, household size, farmer's education and spouse's education in crude oil producing areas had negative relationships with the output of cassava. These results were expected in the crude oil producing communities due to the social influence of multinational oil companies operating in the area. However, marital status, farm size, food crop farming experience and farmer's income were directly related to output of cassava. These results were unexpected in crude oil producing communities. Nevertheless, they might be attributed to the high potential of cassava to thrive and yield relatively well, even on impoverished soils.

Table 4: Regression Results for Cassava Component in CBCM in Non-Crude Oil Producing Communities

Variables	Double-log	Linear	Semi-log	Exponential
Intercept	1.7785**	-255.6827	-152602.9758***	9.1031***
	(2.11)	(-0.38)	(-3.39)	(34.93)
Age(X_1)	0.1032**	68.7884	-930.5923	0.0034
	(2.19)	(1.30)	(-0.36)	(0.84)
Sex(X_2)	-0.0377	-1278.2231	-415.0551	-0.0545
	(-1.377)	(1.62)	(-0.29)	(-0.91)
Marital status(X_3)	0.0235	-1787.2724	-1692.8612	0.0133
	(0.30)	(-1.40)	(-0.39)	(0.14)
Farm size(X_4)	0.4546***	663.4481	14883.8503***	0.2348***
	(7.39)	(1.64)	(4.49)	(7.50)
Household size(X_5)	-0.0294	100.3065	-490.8876	-0.0011
	(-1.10)	(0.66)	(-0.35)	(-0.09)
Farmer's education(X_6)	0.1732***	94.2890	7156.1177**	-0.0085
	(2.50)	(0.66)	(2.17)	(-0.78)
Farming Status(X_7)	-0.0379	34.9684	-3840.6478	0.0149
	(-0.57)	(0.28)	(-1.27)	(1.53)
Farming experience(X_8)	0.0610***	40.8064	852.3789	0.0107
	(2.43)	(0.30)	(0.65)	(0.95)
Farmer's income(X_9)	0.5561***	0.0496***	12776.6811***	0.0000007***
	(8.52)	(89.86)	(3.62)	(15.48)
R^2	0.9859	0.9756	0.9590	0.8970
$\bar{R}^2$	0.9831	0.9708	0.9510	0.8769
F-ratio	178.42	169.27	72.75	38.72

( ) t-statistic computed; *** statistically significant at 1%; ** statistically significant at 5%

In the non-crude oil producing areas age, farm size, marital status, farmer's education, food crop farming experience and farmer's income contributed positively to output of cassava. These results agreed with the *a priori* expectation that these socio-economic variables would positively influence cassava farmer's performance in terms of output. Sex, household size and spouse's education showed inverse relationships with output of cassava in non-crude oil producing area and their t-values were not significant at the 5% level of confidence.

Furthermore, the equality of coefficient in the lead equations from based or lead crop component in crude oil and non-crude oil producing areas was tested using the Chow test since there were also observed relationship between output of CBCM farmers and socio-economic factors in both areas. The result of the F* ratio for cassava, maize and melon components was 30.01, while the theoretical value of F at the 99 per cent level of significance with $V_1 = 10$ and $V_2 = 80$ degrees of freedom was 2.58. Thus, $F^* > F_{0.01.}$ It also implied that the food crop outputs and socio-economic characteristics of CBCM farmers' relationships in crude oil and non-crude oil producing communities differed significantly.

3.4 Conclusion and Recommendations

The study revealed dissimilarities in socio-economic characteristics of CBCM farmers in crude oil and non-crude oil producing areas. It, therefore, implies that crude oil exploitation activities in crude oil producing area that adversely affected the agro climate of the area have actually influenced the socio-economic characteristics of the CBCM farmers in the area.

The output levels of crop components of CBCM farmers in non-crude oil producing areas were significantly higher than those of crude oil producing areas. This result is indeed attributed to agro climatic change on the crude oil producing area by crude oil exploitation. For cassava component of CBCM in the area, socioeconomic variables combined influence on its output was significant at the 1% level of probability. The Chow test on based crop component in CBCM showed that output and socioeconomic characteristics of CBCM farmers' relationships in crude oil producing area and non-crude oil producing area differed significantly. Based on the study findings, researches should be carried out on ecological, sociological and agro-climatic changes in crude oil producing area as to proffer acceptable adaptation measures that will better livelihood of food crop farmers in the area. Oil companies operating in the area should endeavour to change their operational procedures in order to reduce the rate of environmental pollution due to oil exploitation.

References

Aju, P.C. (1999). *Determinants of the Uses of Fallow and On-Farm Trees/Shrubs and Farm Practices in Imo State,* (Unpublished M.Sc. Thesis). Department of Forestry Resources Management, University of Ibadan.

Akwiwu, C. D. (2002), *Determinants of Adoption of Agro forestry Technologies and the Market of the Produce in Crude Oil Producing Areas of Imo State,* (Unpublished M.Sc. Thesis). Department of Agricultural Economics and Extension, Imo State University, Owerri.

Akwiwu, C.D., C.U. Nwajiuba and F.N. Nnadi(2002).*Oil Pollution and Agro-forestry Practices of Farmers in Imo State: Implications For Household Livelihood.* Proceedings of 36thS Annual Conference, Agricultural Society of Nigeria, Federal University of Technology, Owerri, Nigeria. Oct. 20-24, 2002: 25-28.

Alam, J.B., A.A.M. Ahmed and G.M. Munna. (2010). Environmental Impact Assessment of Oil and Gas Sector: A Case study of Magurchara Gas Field. *Journal of Science, Environment and Management* 1(5): 86-91.

Awobajo, S.A. (1983). *An Analysis of Oil Spill Incidents: 1980 – 1987,* in Thomopulose. A.A. (ed), The Petroleum Industry and the Nigerian Environment; Proceedings Of the Warri 1981, International Seminar, Nov. 9 –12. Lagos, Pp. 57-63.

Center for Rural Affair (CRA) (2007). *Climate Change and Agriculture*: Report of a Center for Rural Affair Task Force.

Eze, C.C., B.O. Amanze, C.U. Nwajiuba and C.S. Nwosu (2009).*Costs and Returns of Arable Crop Production among Small-holder Farmers in Owerri Agricultural Zone of Imo State, Nigeria,* Proceedings of the International Conference on Food Crisis, Held at Federal University of Technology, Owerri, Nigeria. April 19-24, 2009.

Imo State Agricultural Development Programme (ImoADP) (2000). "An Assessment Study of the Performance of the National Agricultural Technology Support Project in Imo State with Focus on Farmers Adoption of Technologies and their Socio-economic Improvements." Cochita Nig. Ltd.

IPCC (1996). "Climate Change 1995: The Science of Climate Change". Contributions of Working Group 1 to the 2nd Assessment Report of Inter-governmental Panel on Climate Change (IPCC); Houghton, J.T. (Eds) Cambridge University Press, UK.

IPCC (2007). Summary for Policymakers. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of the Working Group II to the Fourth Assessment Report of the Inter- governmental Panel on Climate Change, Pary, M.L, O.F. Canziani, J.P. Palutikof, P.J. Van der Linden and C.E. Hanson, (Eds) Cambridge University Press, UK. 7-22.

Koutsoyiannis A.(1979), *Theory of Econometrics,* (2nd Ed)., London: Macmillian Publishers Ltd.

Mejeha, R.O. (1991), *The Demand for and Delinquency Problems of Formal Agricultural Loans by Small-Holder Farmers in Owerri Agricultural Zone of Imo State,* (Unpublished M.Sc Thesis). Department of Agricultural Economics, University of Nigeria.

NEST (1991). Nigerian Threatened Environment: A National Profile, Nigerian Environmental Study/Action Team (NEST), Ibadan. Nigeria.

Nwaru, J.C. (1993), A Comparison of the Allocative Efficiency of Cooperative and Non-Cooperative Farmers in Food Crop Production in Imo State Nigeria, Nigerian *Journal of Agricultural Teachers Education*, Vol. 1 & 2, Pp 139 – 148.

Njoku, D.C. (1995). *Effect of Oil Prospecting on Aquatic Ecosystem and Socio-Economic Implication on Resource Poor Fishing Communities in Nigeria.* A Paper Presented at the National Conference of the Nigeria Society for Biological Conservation, Nov. 12-15, Umuahia, Nigeria.

Nwosu, C., C. Nwachukwu and N. Duru (2008). "Effects of Climate Change on Food Crops Farmers in Crude Oil Producing Communities in Imo State. In: Chinedum Nwajiuba (Ed.), *Climate Change and Adaptation in Nigeria. Farming and Rural Systems Economics,*Volume 95, Pp 73-80, Margraf Publishers, Germany.

Okoli, G.C. (2006). Rural Households Perception of the Impact of Crude Oil Exploration in Ogba/Egbema/Ndoni Local Government Area of Rivers State, Nigeria. *Journal of Agriculture and Social Research (JASR),* Vol.6, No.2, 2006.

Olemeforo, P.N.C. (2000). *Possible Socio-economic Aspect of the New Found Oil and its Exploitation in Imo State,* Paper Presented at the Inauguration of the Institute ofEnvironmental Managers in Owerri, Nigeria.

Olowu, T.A., A.I. Iloka, and J.A. Ekpere (1990). Farmers Characteristics and Adoption of Improved Cassava Varieties in Imo State, Nigeria, *Proceedings of the Nigerian Academy of Science,* Vol. 2.

Pernar, N., D.Baksi, O. Antonic, M. Grubesic, I. Tikvic and M. Trucevic (2006). Oil Residuals in Lowland Forest Soil after Pollution with Crude Oil. *Water, Air and Soil Pollution,* 177: 9(1-4): 267-284.

Sombroek, W.G. and R. Gommes (1990). *The Change- Agriculture Conundrum,* originated by Natural Resources Management Department, FAO, Rome Italy.

Ukaegbu, O.D. and A.O. Okeke (1987), Flaring of Associated Gas in Oil Industry – Implication on Growth, Productivity and Yield of Selected Farm Crops in Izombe, in *NNPC: The Petroleum Industry and the Nigerian Environment,* Lagos, Pp. 302 –331.