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**Research Article**

# Impact of SPDC-Bomu Manifold Oil Pipe Explosion Fire on Crop Yield and Farm Income in Gokana LGA, Rivers State, Nigeria

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**Abstract:** Environmental degradation of the oil-rich Gokana Local government area has been wanton and continuous with dire health, social and economic consequences for its peoples, for over three decades. The study was based on the result of environmental impact studies conducted on the SPDC-Bomu manifold oil pipe explosion of 12th April, 2009 and its impact on agricultural production in K-dere, Deken, Kpor and Biara communities. Using a sample of 400 crop farmers drawn randomly from the 4 communities, the negative impact of hydrocarbon fire on crop production was accentuated. Hydrocarbon fire caused acid rain that reduced crop yield, land productivity and greatly depressed farm income as a 10 percentage increase in hydrocarbon fire reduced crop yield by 13% while farm income plummeted by 25.5%. In order to halt the continual degradation of the Niger Delta environment, the authors recommend enactment and enforcement of stringent environmental laws to protect the area as well as the implementation of policies to reduce the crushing level of poverty and guarantee a better livelihood for the people.

**Keywords:** Hydrocarbon fire, land productivity, low crop yield, natural resource degradation, small-scale farmers

## INTRODUCTION

Global demand and revolutionary advances in science and technology have continued to propel the rate and possibilities of oil and gas extraction leading to more and more wealth and revenue thus lifting humanity to a new height of prosperity and longevity in many parts of the world. Perversely, many communities rich in such natural resources remains poorer due to neglect and the consequences of continuous hazardous impacts of bad resource exploitation activities. The result has been severe threat to human and environmental health with potential risk of unprecedented magnitude to the survival of future generation (Bierregaard, 2001).

Studies prove that today, approximately one out of every six people on the planet subsists on less than a dollar per day. In a situation where the world's population is estimated to increase to about 9 billion people by the year 2050, further straining earth's resources and humanity's ability to thrive making sustainable livelihood more critical, (Chindah and Braide, 2000; UNCCD, 2002) predictably, in this environmentally dependant world, persistent reckless exploitation of nature with less regard to the environment will lead human survival on the brink of collapse. Climate change for instance, has been universally recognized as a global problem ravaging and compounding the woes of humanity (CIA World Factbook, 2007). While, historically the preponderance of greenhouse gas emission have been in the areas of industrial operations in developed countries, hydrocarbon fire resulting from equipment failure is rapidly increasing its atmospheric concentration in rural communities of the Niger Delta, Nigeria.

Like many other southern communities in Nigeria, Gokana local government communities in Ogoni, Rivers State continue to suffer the woes of oil exploitation operations. Oil spillage and atmospheric pollution caused by "lack of maintenance services, rusty damages and leaked pipes" is an unfortunate perennial problem plaguing the area. The Bomu Manifold located in Kegbara Dere, is one major source of many oil spills in the local government area. Between 1994 and 2009, oil pipe leakages at the facility has caused four (1994, 2001, 2003 and 2009) major oil spills. In April, 2009 leaked oil pipes at the Manifold operated by Shell Petroleum Development Company (SPDC) Nigeria Limited caused huge explosion that led to high column of hydrocarbon fire and emission of volume of pollutants into the atmosphere of the local communities, (Gilgal, 2009). On a global scale, it is generally acceptable that such development degrades air quality and contributes to climate change and global warming. Spencer (2003a, b) and Awah (2005), posit that it causes acid rain with inevitable disastrous consequences on soil, biological community and agricultural productivity.

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Gokana Local Government area is a rural community that stuck to their traditional method of land cultivation as the only means of food provision for its population. Consequently, persistent atmospheric upload of green house gases from Hydrocarbon fire and the associated environmental consequences will pose tremendous challenge to the possibilities of sustainable food provision for the people of the area.

The continuity of such ugly scenario can be complex and quite critical and therefore, require diligent attention with a view to determining the consequences in terms of food security for present and future generation of the Gokana people.

**The problematic:** All stages of oil exploitation impact negatively on the environment and the greatest of the intractable environmental problem caused by crude oil exploration activities in the Niger Delta region is oil pipe leakage. According to DPR (1997), over 6,000 spills had been recorded in the 40 years of oil exploitation in Nigeria with an average of 150 spills per annum. In the period 1976-1996, 647 incidents occurred resulting in spillage of 2,369,407.04 barrels of crude oil with only 549,060.38 recovered. 1, 820,410.50 barrels lost to the ecosystem.

In 1970, oil well eruption at SPDC oil well number 11 in Kegbara Dere-Bomu oil field resulted in serious hydrocarbon fire and spillage of thousands of barrels of crude oil that negatively impacted tremendously on adjoining creeks and mangrove forest and rendered vast agricultural land barren till date.

In 1994 ruptured oil pipe at Bomu Manifold caused spills of high magnitude that devastate vast land belonging to Kegbara Dere, Bera, Kpor, Mogho Goi and Bodo communities. During the year 2001 and 2003 respectively, leaked oil pipes at the facility caused oil spillages that devastate vast swamps and creeks. In 2009, “rusty damages and leaked pipes” at the same Manifold resulted in huge explosion that caused hydrocarbon fire and emission of gaseous substances and other pollutants in to the environment beyond acceptable limit (Gigal, 2009). According to Gigal (2009), the development caused acid rain in the area and poses danger to humans, animals, plant health and crop yield. The results indicate clearly that the rain water is quite unsafe for domestic uses (Table 1 to 3).

In 1998, the National Acid Precipitation Assessment Program (NAPAP) identified that the combination of rain and oxides is part of a natural balance that nourishes plants and aquatic life. However, when the balance is upset, the results to the environment can be harmful and destructive.

Acid rain is believed to change soil chemistry and harm vegetation. Soils exposed to acid rain can gradually lose valuable nutrients, such as calcium, magnesium and potassium and become too concentrated with dissolved inorganic aluminum, which

Table 1: Result and parameters investigated on rain water quality in Kegbara Dere community

| Physiochemical parameters | Specification/WHO guidelines | Actual result |
|---|---|---|
| pH | 6.5-8.5 | 3.150 |
| Chloride | 250 mg/L | 502.000 mg/L |
| Alkalinity | 250 mg/L | 335.000 mg/L |
| Conductivity | - | 1,220 µS/cm |
| Salinity | - | 10 ppt |
| Total hardness | 400 mg/L | 690.066 mg/L |
| Taste and odour | Unobjectionable | Objectionable |
| Color | 15 hagen units | 19 hagen units |
| Turbidity | 5 NTU | 7 NTU |
| Lead | 0.01 | 0.030 mg/L |
| Iron | 0.3 g/L | 0.020 mg/L |

Sample location: Open field, community primary school 1; Date of collection: 18/05/2009; Date of analysis: 18/05/2009; Gilgal academic and integrated services (2009)

Table 2: Result and parameters investigated on rain water quality in Deken community

| Physiochemical parameters | Specification/WHO guidelines | Actual result |
|---|---|---|
| pH | 6.5-8.5 | 4.35 |
| Chloride | 250 mg/L | 347.00 mg/L |
| Alkalinity | 250 mg/L | 110 mg/L |
| Conductivity | - | 348 µS/cm |
| Salinity | - | 5 ppt |
| Total hardness | 400 mg/L | 550 mg/L |
| Taste and odour | Unobjectionable | Objectionable |
| Color | 15 hagen units | 18 hagen units |
| Turbidity | 5 NTU | 5.80 NTU |
| Lead | 0.01 | 0.42 mg/L |
| Iron | 0.30 | 0.01 mg/L |

Sample location: Open field, Deken health center; Date of collection: 25/05/2009; Date of analysis: 25/05/2009; Gilgal academic and integrated services (2009)

Table 3: Results and parameters investigated on rain water quality in Biara community

| Physiochemical parameters | Specification/WHO guidelines | Actual result |
|---|---|---|
| pH | 6.5-8.5 | 3.200 |
| Chloride | 250 mg/L | 330.000 mg/L |
| Alkalinity | 250 mg/L | 160.000 mg/L |
| Conductivity | - | 380 µS/cm |
| Salinity | - | 5 ppt |
| Total hardness | 400 Mg/L | 610.000 mg/L |
| Taste and odour | Unobjectionable | Objectionable |
| Color | 15 Hagen units | 16 Hagen units |
| Turbidity | 5 NTU | 9.400 NTU |
| Lead | 0.01 | 0.025 mg/L |
| Iron | 0.30 G/L | 0.010 mg/L |

Sample location open field, C. S S; Biara date of collection: 26/05/2009; Date of analysis: 26/05/2009; Gilgal academic and integrated services (2009)

is toxic to vegetation. Valuable nutrients like calcium and magnesium are normally bound to soil particles and are, therefore, protected from being rapidly washed into groundwater. Acid rain, however, may accelerate the process of breaking these bonds, (Hubbard Brook Research Foundation, 2001; Kudesia and Kudesia, 2007; Narayanan, 2007).

Relationship between soil acidity and nutrients rob the soil of nutrients thereby increasing soil infertility through the destruction of soil micro organism. This, in turn, affects plant uptake of vital nutrients. Research has also found a decrease in carbohydrate production in the photosynthesis process of some plants exposed to acid conditions. Such conditions will inhibit plant growth and food/crop production.

In his study of the socio-economic impacts of oil pollution, Worgu (2000) stated that crude oil exploitation has had adverse effect on soils, forest and water bodies in host communities. Farmers have lost their lands and are consequently forced to emigrate to other communities in search of livelihood exerting additional pressure on natural resources in such area.

According to Stanley (1990), 67.7% of 797 respondents interviewed identified land degradation as the major socio-economic problem associated with oil extraction activities. Although the impact of oil exploitation in the Niger Delta is enormous, the objective of this study is to examine the effect of acidified rain caused by the Bomu Manifold hydrocarbon fire of April 12, 2009 on crop yield, land productivity and farm income in the study area using the following procedure:

- Obtaining and analysing information on yearly annual farm output and farm income level from sales of farm produce two years before (2007-2008) and 2009-2010 after the incidence of April 12, 2009 in four communities with a view to determine and or establish the decline or increase rate (if any).
- Monitoring and documenting the growth and output of annual production of five prominent local farms produce (Yam, Cassava, Three leaf yam, Cocoyam or Taro and Pumpkin and Okro) in the Area for the year 2010.
- Investigating any observable anomalies in crop growth and output, land productivity and the possible cause of increase or decrease in the yearly annual income.
- Determining the implications of such decrease or increase on the people's means of livelihood.
- Making appropriate recommendations based on the findings.

**Significance of the study:** Gokana Local Government area is an agrarian society with over 60% predominantly, engaging in subsistent agriculture as the main source of livelihood. The community play host to oil and gas facilities including the Bomu Manifold in Kegbara Dere operated by SPDC. Oil pipes at the Manifold exploded on the $12^{th}$ day of April 2009 and caused huge column of fire and emission of atmospheric pollutants beyond acceptable limit into the surrounding environment of the Local Government (Gilgal, 2009).

Gilgal (2009) reported that the incidence caused high concentration of Nitrogen oxide, Sulphur dioxide and other gases in low atmosphere within the area and adds that:

- The rate of pollutant dispersal arising from the fire is moderate to low.
- This could lead to a gradual dispersion to the communities and higher concentration therein.
- It also implies that the pollutants could not be rapidly diffused as they dispersed into the communities and the health and infrastructure implications could be severe. For instance, $NO_x$ and $SO_x$ could acidify the rains…, while high CO concentration could affect both human and plant health.
- The atmospheric relative stability conditions as obtained favors gradual dispersion of pollutant into the communities and slow diffusion therein indicating that within the communities the concentration of pollutants will persist even though the fire has been put under control.

The experts report revealed that:

> Nitrogen Oxide ($NO_2$) and Sulphur dioxide ($SO_2$) from the hydrocarbon fire combined with water vapor in the atmosphere to form acid that returns to the earth's surface as acid rain… and that precipitated acid reduces crops yield, acidify surface water and disrupts biological processes of animals and plants.

In a rural community with subsistence economic viability, the conditions predicted in the report suggests that the communities' ability to provide food for its population will be compromised. Therefore, there is pertinent need to investigate and ex-ray the implications and consequences of the menace on food production in the area and analyse the problems arising from its implications on sustainable livelihood.

This would enable us make positive and calculative judgement with regards to awareness creation and or policy implementations.

## MATERIALS AND METHODS

Multistage sampling techniques were used to draw samples for the study. The study area comprise the four communities which was purposively selected based on the report of the post endangerment assessment of the impact of the Bomu Manifold oil pipe explosion conducted in 2009. The communities includes: Kegbara Dere, Kpor, Biara and Deken. Out of these four communities, 100 small scale farmers were selected randomly to make a total sample size of 400 farmers used for the study. The data set for the study covers the years 2007, 2008, 2009-2010. This was based on the assumption that farmers will be able to recollect their input and output levels before and after the incidence during this time. To assess and adequately measure the problem under investigation, structured questionnaire, observation technique and direct interview methods were adopted.

The questionnaires were administered personally to respondents. Data collected included crop yield, land area cultivated, labor and capital input, farm income as well as incidence of oil spill and Hydrocarbon fire and their effect on agricultural production. Information on social characteristics of the farmers was also obtained.

**Observation technique:** Two farms each was monitored in the four selected villages coded A-D. One farm (coded site A1) planted with yam, pumpkin and cassava were observed in each of the communities and another farm (coded sites A2) planted with cocoyam, three leaf yam and cassava in each of the four villages. Direct field observation was carried out on sites A1 and 2-D1 and 2 beginning from period of farm clearing and planting of fruited pumpkin and yam in January and early February, 2010. Another visit to same sites was made in late April and early May, 2010 when cassava planting and harvesting of pumpkin was ongoing while on sites A2-D2 visits was made in early June and July, 2010 when cocoyam and three leaf yams are respectively being planted.

In June and July, 2010 being peak of pumpkin harvest, four visits were made to sites A1-D1 and the central market (Kibangha). Other visits to same sites were made in late August and September and in late October during period of yam harvesting.

Final visits were made to sites A2-D2 in all the four villages during the month of December, 2010 and to the local market and the popular Kibangha market.

During visits to the respective sites, observations were recorded using field notes and interviews conducted with farmers whereas during visits to the market, observations were recorded and interviews with traders on farm produce were made. Estimated cost of labor which varies from place to place depending on the time and cost of seedlings, fertilizer, pesticides and stakes for the yam were considered.

**Model specification and estimation:** In order to estimate the effect of acid rain from the caused by the hydrocarbon fire on crop production, the following econometric models relating crop yield, land productivity and farm income with the under listed explanatory variables were specified and subsequently estimated:

$$CRPYD = f\ (LNDSZ, LBR\ NT\ PLT\ MT, FRM\ XP\ CPT\ NT, HCF, \varepsilon) \quad (1)$$

$$LNDTY = f\ (LBR\ NT\ PLT\ MT, FRM\ XP\ CPT\ NT, HCF, \varepsilon) \quad (2)$$

$$FRMNC = f\ (CRPYD, MKTPZ, HCF, \varepsilon) \quad (3)$$

where,

| | | |
|---|---|---|
| CRPYD | = | Annual household crops yield |
| LNDTY | = | Land productivity measured as the ratio of crop yield to land size |
| FRMNC | = | Equals the returns after deducting or costs of production |
| LNDSZ | = | Land size cultivated measured in hectares |
| LBR NT | = | Labor cost per cropping season |
| PLTMT | = | Cost of planting materials |
| CPTNT | = | The depreciation cost of capital inputs |
| FRMXP | = | Farming experience measured as number of years in crop farming |
| HCF | = | Hydrocarbon fire dummy (Hydrocarbon fire = 1, no fire during cropping year = 0) |
| MKTPZ | = | Average market price for the quantity of crops produced |
| ε | = | The error term |

Because economic theory does not indicate the precise mathematical form of the relationship among the variables, different functional forms of the above models including the linear, semi-logarithm, logarithm and exponential functions were fitted. However, the lead equations were chosen on the bases of economic, statistical as well as econometric criteria (Koutsoyiannis, 1977; Olayemi, 1998; Odjuvwuederhie *et al*., 2006; Inoni *et al*., 2006). The semi-logarithmic, exponential and logarithmic functions were fitted for crop yield, land productivity and the farm income models respectively as follows:

$$CRP \downarrow YD = 1n(\downarrow 0 + \downarrow 1\ 1nLNDS) + (\downarrow 29LBR \downarrow NT (\downarrow 3I \downarrow N\ PLT \downarrow MT + \downarrow 4 \downarrow I \downarrow N\ FRM \downarrow XP + (\downarrow 5I \downarrow N\ CPT \downarrow NT + (\downarrow 6\ HC \downarrow F \quad (4)$$

$$I \downarrow N\ LND \downarrow = (\downarrow 0 + (\downarrow 1\ LBR \downarrow NT + (PLT \downarrow NT + (\downarrow 3\ FRM \downarrow XP + (\downarrow 4\ CPT \downarrow NT + (\downarrow 5\ HC \downarrow F \quad (5)$$

$$I_N\ FRM_{NC} = I_N\ Y_0 + Y_1\ I_N\ CRP_{YD} + Y_2 I_N MKT_{PZ} + Y_3 HC_F \quad (6)$$

where, the variables are as defined earlier in Eq. (1) to (3) above. The Ordinary Least Squares (OLS) technique was used to estimate the regression parameters.

## RESULTS AND DISCUSSION

**Socio-economic analysis:** The socio-economic characteristics of the farmers surveyed are presented in Table 4. The results indicate that 43% of the farmers had ages ranging between 45-53 years, with an average age of 48.5 years. With such an aged agricultural work force and agricultural productivity will expectedly be high. Rural-urban migration of able-bodied young men and women, as well as low agricultural income earning due to land resource degradation are equally implicated for the age of active farmers.

A relatively large household size was found in the study, with a mean size of 8 persons/household. About 35.5% of the households have a family size that ranged between 7-9 persons, thus supporting the preponderance of large family sizes among the poor in

Table 4: Factors affecting crop yield and land productivity in the study area

| | Crop yields model (semi-log function) | | | Land productivity model (exponential function) | |
|---|---|---|---|---|---|
| Variable | Estimated coefficient | t-statistics | p-value | Estimated coefficient | t-statistics |
| Land use | 703.75 | 2.11 | 0.04* | | |
| Labor input | -77.29 | -0.33 | 0.74 | -0.86E-05 | -0.408 |
| Planting material | 483.27 | 2.07 | 0.04* | 0.25E-04 | 2.180 |
| Farming experience | 310.20 | 1.65 | 0.10 | 0.72E-02 | 1.060 |
| Capital input | 2076.80 | 9.81 | 0.00** | 0.35E-03 | 7.950 |
| Hydrocarbon fire | -468.94 | -2.40 | 0.02* | -0.10 | -2.090 |
| | F-stat = 16.59 | | F-stat =16.59 | | |
| | DW-stat = 1.87 | | DW-stat = 1.87 | | |
| | Adjusted R-squared = 0.61 | | Adjusted R-squared = 0.61 | | |
| | | N = 400 | | N = 400 | |

*: Significant at the 5% level; **: Significant at the 1% level

Table 5: Distribution of socio-economic characteristics of respondents (N = 400)

| Age of farmer | Frequency | Mean/ (mode) | Educational level | Frequency | Mean/ (mode) |
|---|---|---|---|---|---|
| 27-35 | 25 (6.25) | | No. formal education (1) | 211 (52.70) | |
| 36-44 | 65 (16.25) | | Primary school (2) | 132 (33) | 1.0 |
| 45-53 | 172 (43) | 48.5 years | Secondary school (3) | 55 (13.75) | |
| 54-62 | 108 (27) | | Tertiary (4) | 2 (0.50) | |
| 63-71 | 30 (7.50) | | | | |
| House hold size | | | Annual farm income (N) | | 42,500 |
| 3-6 | 108 (27) | | 1,900-34,000 | 72 (18) | |
| 7-9 | 142 (35.50) | 8 persons | 35,000-50,000 | 205 (51.25) | |
| 10-12 | 132 (33) | | 51,000-66,000 | 72 (18) | |
| 13-16 | 21 (5.25) | | 67,000-82,000 | 61 (12.75) | |
| Farm size (ha) | | | Gender of farmers | | Male |
| 0.5-0.7 | 94 (23.50) | | Female | 213 (45.00) | |
| 0.8-1.0 | 178 (44.50) | | Male | 187 (55.00) | |
| 1.1-1.3 | 47 (11.75) | 0.9 | | | |
| 1.4-1.6 | 30 (7.50) | | | | |
| 1.7-1.9 | 28 (7) | | | | |
| 2.0-2.2 | 23 (5.75) | | | | |

Computed from survey data (2010)

rural areas of Nigeria (Eboh, 1995). Though a large family size may constitute a social burden, larger families use their labor input to an advantage in farming and forest products exploitation. In fact, the intensity of agricultural production has been found to have a direct relation to household size (Adhikari, 2002). A major proportion of the crop farmers sampled had no formal education (52.75%), while 33% of them had only primary education. On the whole 46.8% of the respondents had some form of formal education, an observation which tends to refute the alarming rate of illiteracy prevalent in rural communities.

The mean level of educational attainment is 1.0 and the implication of this is that on the average, almost every farmer in the study area had primary education.

The sizes of farm holdings in the area are also presented in Table 5. The average farm size is 0.9 hectare. However, 44.5% of the respondents have farms ranging between 0.8-1.0 ha. Such land fragmentation due to traditional ownership structure is antithetical to agricultural growth, because it does not support mechanized and commercial farming.

The level of income realized from crop farming indicates that about 70% of farm income is very low especially in 2010. Annual farm income ranged between N19, 000.00-N82, 000.00, though about 69.25% of the farmers actually earned income of between N19, 000.00-N50, 000.00 from crop farming operations. The average farm income was N42, 500 as against annual farm income range of N92, 000-N240, 000 with average annual income of N121, 000 in 2008.

The survey observed suppressed growth and scorch at the base and leaf margin with White-brown lesions and bleached spots especially in yam, pumpkin and three-leaf yam. In the case of cassava, there is general scorched and withered leaf at period near maturity. This development is an indication of serious soil degradation due to acidity conforming to Narayanan (2007). Acid rain has distinct effect on soil microbiology and chemistry. Acidified rain water enhances soil degradation and loss fertility by leaching off nutrient out of soil leading to necrotic lesions on foliage and long-term damage on topsoil. Specie of cocoyam- Taro locally called ‘Tokogbohr’ or ‘Nkomdee’ that takes much water for growth are most affected. The study reveals that as at 2010, the special food crop (Taro) is extinct in the area. This is almost the case with three-leaf yam.

Farmers’ awareness on the variable causative factors to the problem of poor crop yield is generally low. Over 90% of respondents interviewed confirm outright ignorance of impact of hydrocarbon fire on agricultural productivity.

**Test of differences of means:** The results of the test of differences of means of important production

Table 6: Test of differences of means of crop yield, land productivity and farm income

| Production parameter | Mean difference | d.f | t-value | p-value |
|---|---|---|---|---|
| Crop yield (kg) | 288.862 | 391 | 2.825 | 0.0051* |
| Land productivity | 771.201 | 391 | 7.876 | <0.0001** |
| Farm income (N) | 15718.720 | 391 | 19.088 | <0.0001** |

*: Significant at the 5 % level; **: Significant at the 1 % level

Table 7: Elasticity estimates of crop yield, land productivity and farm income with respect to specified explanatory variables

| | Dependent variables | | |
|---|---|---|---|
| Independent variable | Crop yield | Land productivity | Farm income |
| Land size | +0.20 | - | |
| Labor input | -0.02 | -0.04 | |
| Planting material | +0.13 | +0.25 | |
| Farming experience | 0.09 | 0.10 | |
| Capital input | +0.58 | +0.72 | |
| Hydrocarbon fire | +0.13 | ±0.01 | +0.255 |
| Market price | - | - | 0.040 |
| Crop yield | - | - | +0.050 |

+: Independent variables that have statistically significant effects on the dependent variables; Computed from survey data (2010)

parameters such as crop yield, land productivity and farm income before and after the incidence are shown in Table 6. The results indicate that the effect of the hydrocarbon fire has a statistically significant effect on crop yield, land productivity as well as farm income.

The results are similar to those of Baker (1970b), Gbadegesin (1997) and Ihejiamaizu (1999) in studies they conducted in oil producing communities in the Niger Delta.

**Regression results:** The result of the OLS estimates of the regression parameters in Eq. (4), (5) and (6) for crop yield, land productivity and farm income respectively are presented in Table 4. The results indicate that land size, planting materials, capital inputs and the effect of the hydrocarbon fire have a statistically significant effect on crop yield in a manner consistent with prior expectations. However, the impact of labor input on yield was negative but not significant.

The negative influence of labor on crop yield may be adduced to the fact that optimum levels of labor supply have been reached, thus further employment of labor exerted diminishing effect on crop yield. The fit of the model was good with an Adjusted $R^2$ of 0.81; implying that all the independent variables jointly explains 81% of the variation in crop yield.

The results of the land productivity model are also shown in Table 4. Similar to the crop yield model, planting material, capital input and impact of the hydrocarbon fire had statistically significant effects on land productivity. The incidence of hydrocarbon fire and the consequent acid rain impacted negatively on land productivity because yields reduce due to the poor fertility of the soil and growth performance of crops. Thus with dwindling yield and constant land area, land productivity is bound to fall. However, with an Adjusted $R^2$ value of 0.48, the explanatory ability of the model is poor compared to that of crop yield.

The estimated regression result for the farm income model (6), are shown in Eq. (7). Although the signs of the independent variables are quite consistent with theoretical expectations, only crop yield and the effect of the acid rain had statistically significant influence on farm income, with the effect of acid rain being very highly significant:

$$I_N FRM_{NC} = 10.30 + 0.0051 I_N CRP_{TD} + 0.038 L_N MKT_{PZ} - 0.255 HC_F \quad (7)$$

This result further accentuated the negative impact of the hydrocarbon fire on crop production as farm income is depressed due to the twin effects of land degradation and poor plant growth.

The elasticity estimates of crop yield, land productivity and farm income with respect to the explanatory variables for each of the models are shown in Table 7. For crop yield, a 10 percentage increase in land size cultivated and capital input used will increase crop yield by 2 and 6% respectively, while the same proportional change in effect of the hydrocarbon fire under same meteorological condition will depress yield by 13% These are very significant changes given the dearth of fertile arable land in the study area; itself a consequence of environmental degradation. The fire dummy appeared to exert the greatest impact on farm income, as a 10% increase will decrease farm income by as much as 25.5%.

## CONCLUSION

The hazardous impact of oil exploitation on the degradation of the environment of the Niger Delta region of Nigeria has raised questions of great concern to stakeholders, particularly oil producing communities who have suffered polluted air, water resources, degraded forests and farm lands and very high atmospheric temperatures for over thirty years. While a number of studies have been commissioned by oil companies operating in the area on the socio-economic effects of their operation in host communities, independent studies on the environmental impact of exploitation activities on the health, social and the economic life of the people have not been conducted. Moreover, the wanton and continuous destruction of the ecosystem by oil producing companies is aggravated by the lack of political will by the Federal Government to enact and enforce stringent environmental laws to regulate the environmental consequences of crude oil exploration and exploitation in the Niger Delta.

This study therefore, considered the effect of the environmental pollution arising from the SPDC-Bomu manifold explosion of 12th April, 2009 on food crop production using primary data obtained from 400 small-scale crop farmers drawn randomly from 4 communities in Gokana LGA in the oil producing agro-ecological zones of Ogoni in Rivers State. The study revealed that the incidence has a negative and statistically significant impact on crop yield, land productivity and farm income in a manner consistent with economic expectation. Therefore, in order to halt the continual degradation of the communities of K-Dere, Deken, Kpor and Biara environment, the Federal Government must play a leading role by enacting and enforcing stringent environmental laws that will protect not only the area investigated in this study but the oil producing areas, as well as guarantee the people a better livelihood. Deliberate intervention policies must be implemented speedily to embark on massive infrastructural development of the region, as well as address the crushing level of poverty among the peoples of the Niger Delta.

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