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Research Paper

GIS Analysis and Economic Evaluations of Oil and Gas Field Development Project

Ahmad Abdulhameed [1], Mahmood Abdulhameed[2]AbubakarAbdullahi Yakubu[3]
[1,3]*Department of Survey and Geoinfomatics, Federal polytechnics Bauchi*
[2]*Department of Electrical and Electronics Engineering ATBU Bauchi and SGVU India*

ABSTRACT
This research aim at carrying out GIS analysis and economic evaluations of oil and gas field development project in Nigeria. Oil and gas investment opportunities are regularly proposed to Exploration & Production companies. They may involve the exploration for hydrocarbons in a new area or development of a newly discovered oil or gas field. Many uncertainties regarding reservoir behavior, development costs, and future energy prices and governments policy should be taking into account. In addition, most International investors are faced with capital constraints and therefore rank their projects in order to obtain the greatest return from a limited budget, therefore, there is need to determined most financially attractive projects. The geospatial data was acquired using a GIS and remote sensing techniques and it was processed in ArcGIS 10.2 version. Comprehensive geospatial map showing regions with oil and gas reserves in Nigeria was produced. The second part determined the economic viability of the oil and gas field development project using Nigerian oil and gas field (J) as case study with an estimated project life time of 20 years. A discounted automated cash flow model was developed using an excel spreadsheet, the results of the cash flow modeling found that the project is viable, with Investors (Contractor's) NPV, IRR and Payback period of 149.787MM$, 20.183% and 3.937 years and the project reached it economic limit at 8 years. One-way sensitivity to production rate, crude oil price, investment cost, and discount rate were carried out using various low and high scenarios to see how the projects NPV is affected. The study recommends re-assessment of impact of petroleum fiscal system on the investors and contractors for further research.

KEYWORDS: *Evaluations, ArcGIS 10.2, Royalty, Tax, Viability, Production Rate, CAPEX,*

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I. INTRODUCTION

Economic assessment of oil and gas field will provide effective and consistent evaluation of investment opportunitiesand lead to the determination of most financially attractive projects. According [1] is an essential part of the process of studying available investment opportunities and supporting decision-making, by using special methodology and scientific analysis to select best options. The economic evaluation can be a main tool and reasonable way to find out best petroleum investment opportunities in terms of cost, revenue and risks. These developments make some associated works easier and may help to increase the available information, decrease cost and risks, and ensure high speed and more accuracy.

Economics is a continuous activity. As far as particular oil or gas fields are concerned, the first analysis will be the exploration economics prior to any discovery. Once oil or gas has been shown to exist within a prospect, economics are needed to decide on whether appraisal drilling is justified. After the final investment decision for field development has been taken, economic analysis is still required. Finally, towards the end of the field's life, it will be necessary to decide when and how to decommission it. Here again the economist will be required to analyses the alternatives.

The majority of management-related problems of an enterprise, including management of oil and gas investments, are lived through under uncertainty, with absence of a priori information necessary for solutions thereof. The lack of any possibility to predict future events and parameters largely affects correct evaluation of investment projects and decreases the realistic possibilities ofinvestment decision-making [2].

This has attracted the interest of so many researchers who have succeeded in putting together different cash flow scenarios to determine the economic viability of oil and gas project.A number of studies have been conducted on the technological (Kaiser, 2010; Offia, 2011; Devold, 2013; Akinwale, 2015) and economic factors (Ayodeleand Frimpong, 2003; Iledare, 2004; Adenikinju and Oderinde, 2009; Adamu et al., 2013) affecting oil and gas field development across the globe and Nigeria in specific. However, there is still a dearth of information on the economic and uncertainties affecting the oil and gas field development.

This research comprises four sections which include; Section 1 introduces the research paper, Sections 2 and 3 discuss on methodology and analysis of results while section 4 provides recommendation and conclution.

1.1 AIM

The Research intends to carry out GIS analysis and economic evaluations of oil and gas field development project (Case study of Nigerian oil and gas field).

1.2 OBJECTIVES

The objectives of the study include**:**

(i) To process a geospatial data and produce comprehensive geospatial map showing states with oil and gas reserves in Nigeria.

(ii) To determine inputs to cash flow model as follows; Production forecast ,Price forecast , OPEX forecast CAPEX

(iii)To determine the profitability indicators of the project as follows; Net present value, Internal rate of return, Payback period

(iv) To examine how profitability of the project varies in response to changes in the assumptions regarding the different component of cash flow (sensitivity analysis).

1.3 PROBLEM STATEMENT/JUSTIFICATION

Investment opportunities are regularly proposed to E&P management. They may involve the development of a newly discovered oil or gas field, or exploration for hydrocarbons in a new area. Taking into account the many uncertainties regarding reservoir behavior, development costs, and future energy prices and governments policy.Meanwhile, considering that most of the international investors are faced with capital constraints and therefore rank their projects in order to obtain the greatest return from a limited budget [3].

There is need to determine effective and consistent evaluation of investment opportunities and also most financially attractive projects.This study is applicable to all capital projects regardless of the dollarvalue; it provides effective and consistent evaluation of investment opportunities and determines the most financially attractive projects critical to financial decision-making.

II. METHODOLOGY

On the GIS aspect of this research, it involves creation of map showing the oil and gas producing states in Nigeria. The spatial data was obtained using a remote sensing approach where the base map was obtained from GRID 3 portal. The data was process in ArcGIS 10.2 version.

The economic analysis involved cash flow modeling, project profitability and sensitivity analysis. To model the cash, flow the first analysis will be to determine inputs to cash flow model which include production, price CAPEX and OPEX forecast as shown by the influentialshown diagram in fig1.

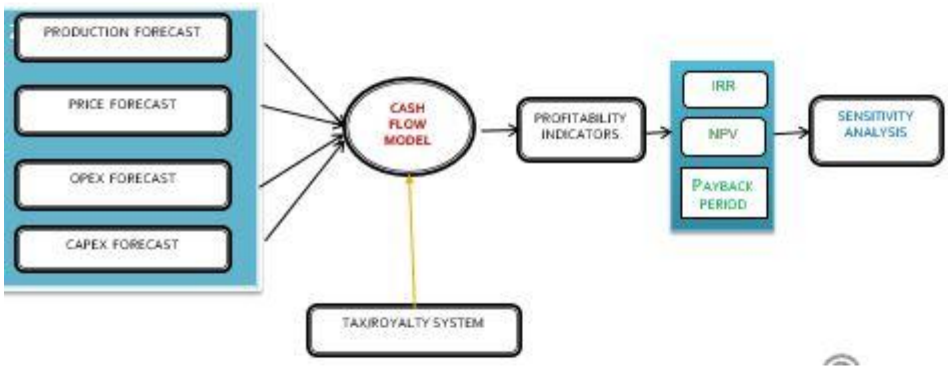

Fig 1

Table: 1

INPUT PARAMETERS		
Production		
Oil production rate in year 1	20MSTB/D	
Decline rate	5%	
Gas oil Ratio	1500SCF/STB	
Investment		
Number of wells	30 wells	
Drilling cost	13 $MM/Well	
Length of pipelines	30 KM	
Diameter of crude pipeline	8 Inches	
Diameter of gas pipeline	12 Inches	
Cost of pipeline	19000 $/Inch-Kilometer	
Cost of production facilities	100 $MM	
Cost of camp	20 $MM	
Operating cost Data @ year 0		**Inflation rate %/yr**
Fuel	4 $MM/Yr	2
Spare Parts	7 $MM/Yr	5
Mainatainace requirement	17 MM/Yr.	6
Salaries	1500 $/Person/Month	1
Caterine& Services	500 $/Person/Day	10
Overhead cost	7 $MM/Yr.	7
Well service & Walkovers	8 $MM/Yr./Well	7
Number of Personnel		
Number of Personnel	30 People	
Cash flow Data		
Crude selling g price 86 $/STB	Escalating at @ 2%/Yr.	
Gas selling price 2 $/MSCF	Escalating at @ 0%/Yr.	
Tax rate 40%		
Discount Rate 10%		
Assumptions		
No Abandonment cost		
Depreciation [straight line{1-10yrs}]		
Royalty = 5%		
Project life = 20yrs		

Table: 2 Sensitivity analysis

Factors investigated	% of base value
Oil price	-20 to +20 and -10 to +10
Oil production rate	-20 to +20 and -10 to +10
CAPEX	-20 to +20 and -10 to +10
Discount rate	-20 to +20 and -10 to +10

Production forecast was done using exponential decline technique, If the initial oil production rate at time t = 0 is q_i, with exponential decline, the oil production rate q_t at some future time t is:

$q_{t,o} = q_i e^{-at}$ .... (1)

The gas production rate at future time can be estimated by taking the product of future oil production rate (q_t) and GOR.

Gas production Rate = ($q_{t,g}$) * GOR ………………………………………….….… (2)

Where: q_i = initial production rate (bopd), q_t = future production rate (bopd), a = instantaneous decline rate, GOR = Gas oil ratio (scf/stb)

The future oil and gas price are modeled using compounded series. Thus the price at any point in the future [P_n] can be represented in terms of the base price [P_o], the annual rate of change in price [F] (escalation rate) and the number of years into the future [n].

$P_n = P_o [1+ F]^n$……………………………………………………………………. (3)

Operating expenditure is the cost that is associated with keeping the production system running perfectly. It is normally quoted as an annual amount and is limited to only productive years. The operating expenditures forecast are carried out by incorporating the inflation rate using equation (3).

The dominant cost element in the early years is the capital expenditure needed for the preparation of platform, production facilities and pipeline and to drill and complete the wells. Capital expenditure forecasts may be estimated from experience, direct quotes or a generalized cost correlation. In certain tax regimes it may be required to allocate capital (and operating costs) based on product streams, as oil and gas projects may receive different tax treatment.

In this study it is assumed the investment will take one year to complete and then start producing.

The main cash-in element is the company's share of the gross revenues derived from hydrocarbon sales. It can be model using production&priceforecast.

The gross revenue in any given year t is computed as:

$[\text{GROSS REVENUE}]_t$ = [OIL REVENUE (stb* $/stb)+GAS REVENUE (scf* $/Mscf)$]_{t}$…(4)

Generally, the treatment of cash flow for R/T systems in full is governed by equation (5) as presented by Iledare (2011):

$NCF_t = GR_t - ROY_t - CAPEX_t - BONUS_t - TAX_t - OTHERS_t$.. (5)

Where: NCF_t= after tax net cash flow in year t, GR_t= Gross revenue in year t, ROY_t= Total royalties paid in year t, $CAPEX_t$ = Total capital expenditure in year t, $BONUS_t$ = Bonus paid in year t, TAX_t= Total taxes paid in year t, $OTHERS_t$ = other cost paid in year t

The economic model developed in this study is based on the governing equations for T/R system presented by Iledare (2011) and the input data presented in table 1& 2.Other assumptions taken include:

a) There was basically no stipulated tax other than income tax that could be charged.
b) Technical Cost Allowed (TCA) = CAPEX + OPEX
c) Fiscal cost allowed (FCA) = Royalty + OPEX + Fiscal depreciation.
d) Modeling is done in years rather than in days or months.

Therefore, the project's cash surplus (or deficit) in any given year (t) is given by

$[\text{CASH SURPLUS}]_t = [\text{REVENUE - OPEX - CAPEX - ROYALTY – TAX}]_t$ ……... .. (6)

$[\text{ROYALTY = ROYRATE x REVENUE}]_t$ ……………………………………...… (7)

$[\text{TAX}]_t = [\text{TAXRATE x (REVENUE - ROYALTY - OPEX - FISC. DEPR.)}]_t$ ....… (8)

2.1 DISCOUNTED CASH FLOW METHOD

The cash flow of a project is the net cash generated or expended on the project as a function of time. The figures are obtained, generally on an annual basis, by subtracting the cash-out (the sum of payments made on behalf of the venture, comprising technical costs and government take) from the cash-in (the sum of payments received as a result of the venture) to give the cash surplus or cash deficit [4]. The time value of money is included in economic analyses by applying a discount rate to adjust the value of money to the value during a base year. Discount rate is the adjustment factor, and the resulting cash flow is called the discounted cash flow.The DCF method is most suited for producing properties in which an income stream is likely and not speculative (Ayodele and Frimpong, 2003).This method is widely adopted when evaluating oil and gas investments by oil and gas companies (Gustavson, 1999).The Net present value of a project is simply the sum of the present values of individual annual net cash flows over the life time of the project. That is the amount by which the present value of earnings is greater than that of payments.

The NPV can be expressed as:

$$\textbf{NPV(r,t)} = \sum_{i=0}^{N} \frac{\text{NCF(t)}}{(1+\text{r})^t} \ldots\ldots (9)$$

Internal Rate of Return (IRR) is the discount rate that equates the present values of net cash flows with the initial project outlay. It is calculated by determining the discount rate at which NPV equals zero.

It's computed as:

$$\sum_{n=0}^{N} \frac{\text{Cn}}{(1+\text{IRR})^n} = \mathbf{0} \ldots\ldots (10)$$

Where NCF (t) = Estimated NCF over the time period t, r = Rate of discount.
When NPV (r, t) >0 then the investment is profitable, otherwise the investment is not profitable. Meanwhile, internal rate of return (IRR) is the discount rate, which reduces the project NPV to zero. NPV of an oil and gas project is a function of oil and gas prices,total oil and gas production, development expenditure, operating expenditure, abandonment expenditure, real discount rate and government taxes among other factors.
Payback period is the time at which the cumulative discounted cash flow becomes positive. It is the break-even point which is the time lapse from initial investment on E&P venture until recovery of investment. All revenues received after the payout period represents profits and new capital generated from the project [4].

$PBP = Y + (L_0\text{-}ACF_g) / CIF_t$………………………………………………………… (11)
Where: PBP = Payback period, Y = Number of years preceding PB, Lo = Initial investment
ACF_g = Gross accumulated NCF for Y, CIF_t = NCF in year where PB exactly occurs

III. RESULTS AND DISCUSION

3.1 PRODUCTION OF COMPREHENSIVE GEOSPATIAL MAP

The data of administrative map of Nigeria was process using ArcGIS 10.2 to produce comprehensive geospatial map showing states with oil and gas reserves in Nigeria as shown in fig 2,

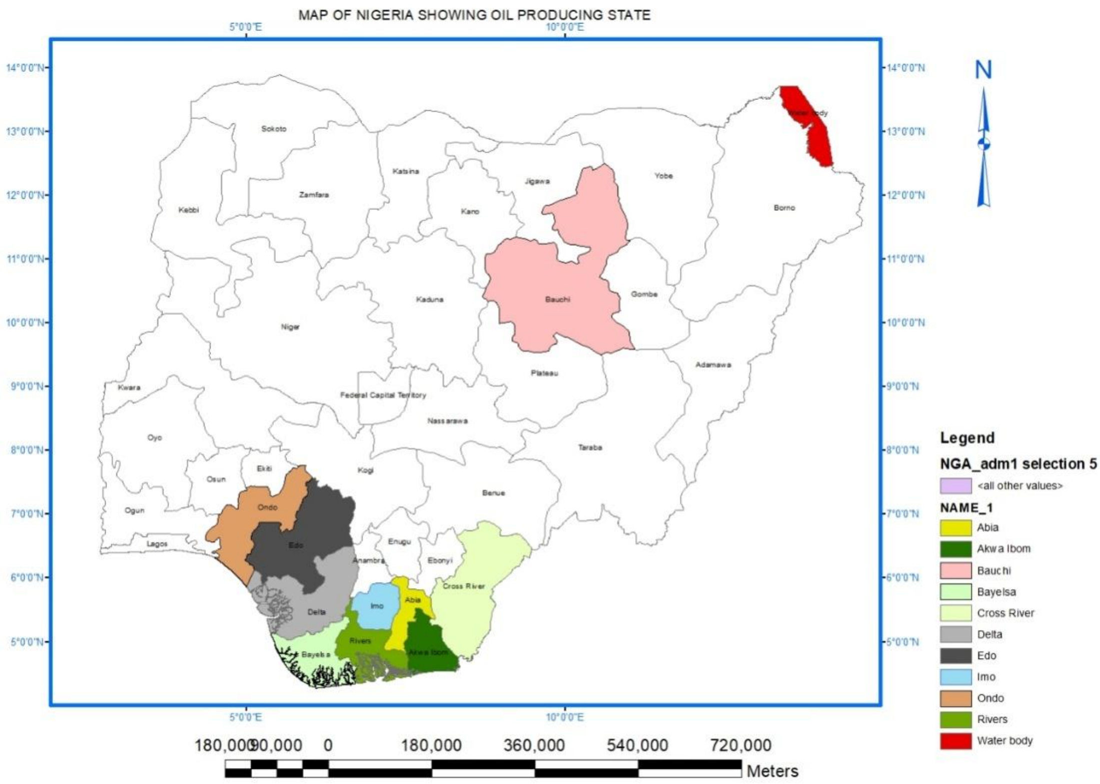

Fig 2,

3.1PRODUCTION PROFILE AND PRICE FORECAST

Fig 2 shows the production profile, the crude oil and gas production starts at 7300MSTB and 10950MSCF in the first year, with oil declining at 5% and the gas production which depends on the crude oil production. The productions continuously decrease until it reaches a minimum of 2823.2095MSTB for the oil and 4243.8142MSCF for the gas in year 20. The cumulative gross production for the oil was 94616.06783MSTB and 141924.10MSCF for the gas.

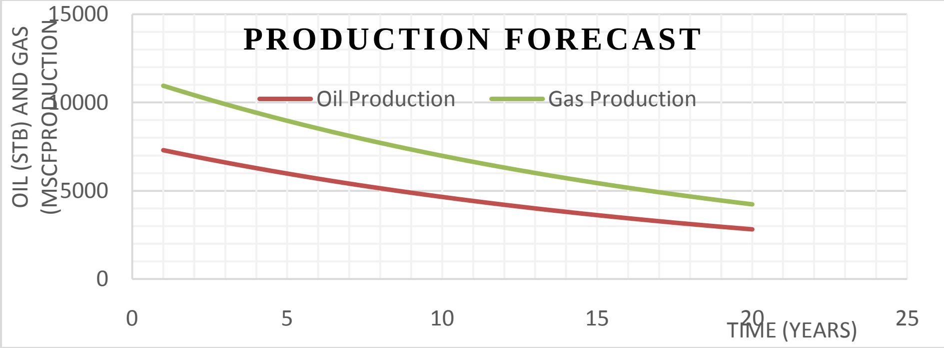

Fig 2: crude oil and gas production profile.

The starting oil and gas prices are 86 $/STB and 2 $/MSCF with oil price escalating at 2% and 0% for the gas. The future oil and gas price are modeled as a compounded series shown in Fig 3.

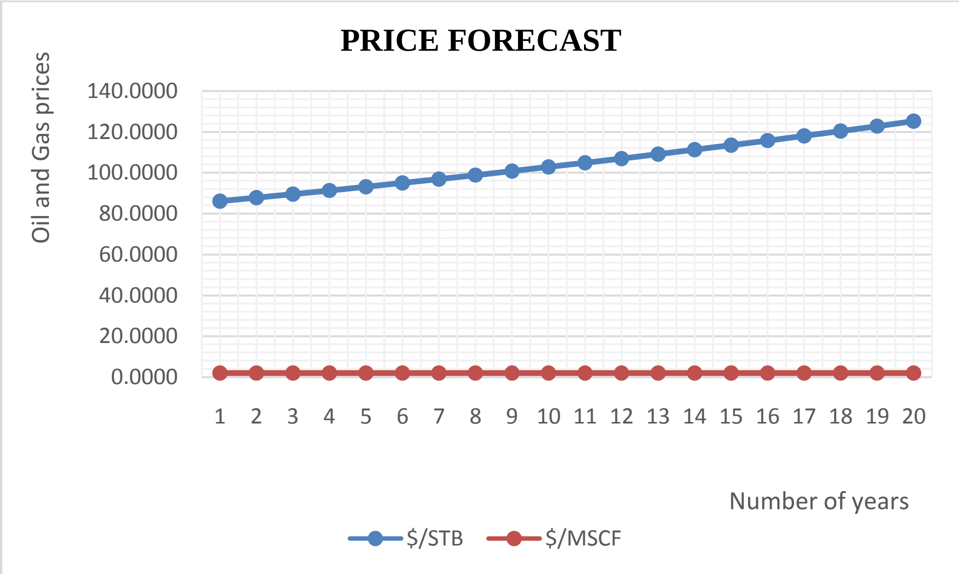

Fig: 3

From the gross production generated for the oil and that of the gas as well the prices of each of the STB and MSCF generated in figure 2 and figure 3, the Gross revenue forecast shown in fig 4, was determine by summing the oil and gas revenue in each respective year. The oil revenue which form by multiplying the oil production (STB) in a given year and the price of the $/STB in that year and the gas revenue also form by multiplying the gas production (MSCF) in any given year by the price ($/MSCF) in that year. The gross revenue is determined each and every year, which is the summation of oil revenue and gas revenue.

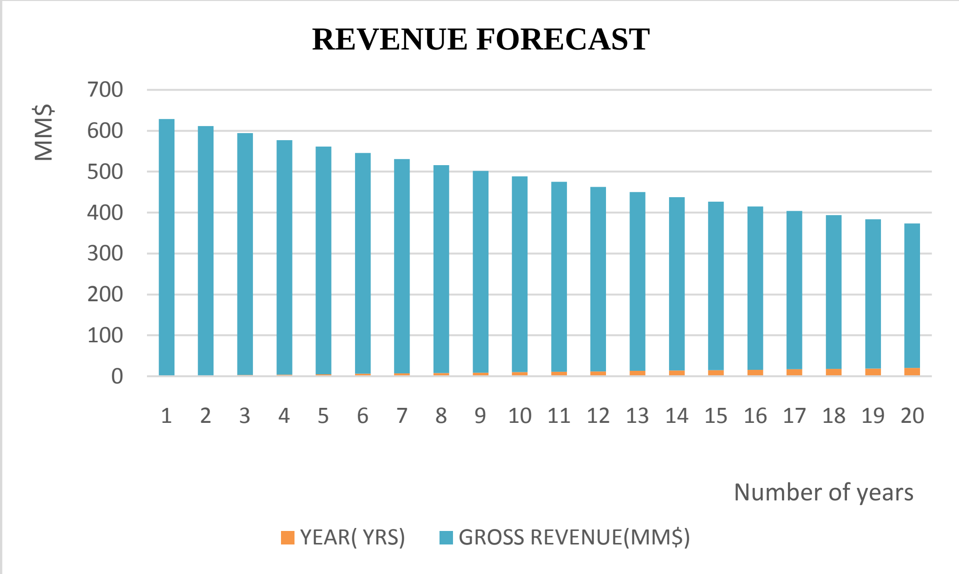

Figure 4: Gross revenue

3.1 CAPEX AND OPEX FORECAST

The dominant cost element in the early years needed to build the platform, production facilities and pipeline and to drill and complete the wells etc. were estimated to be 521.4 MM$ shown in fig 5. The remaining technical costs are the operating cost shown in fig 6, which cover maintenance, salaries, and treatments etc. which are dominant during the last years of the venture.

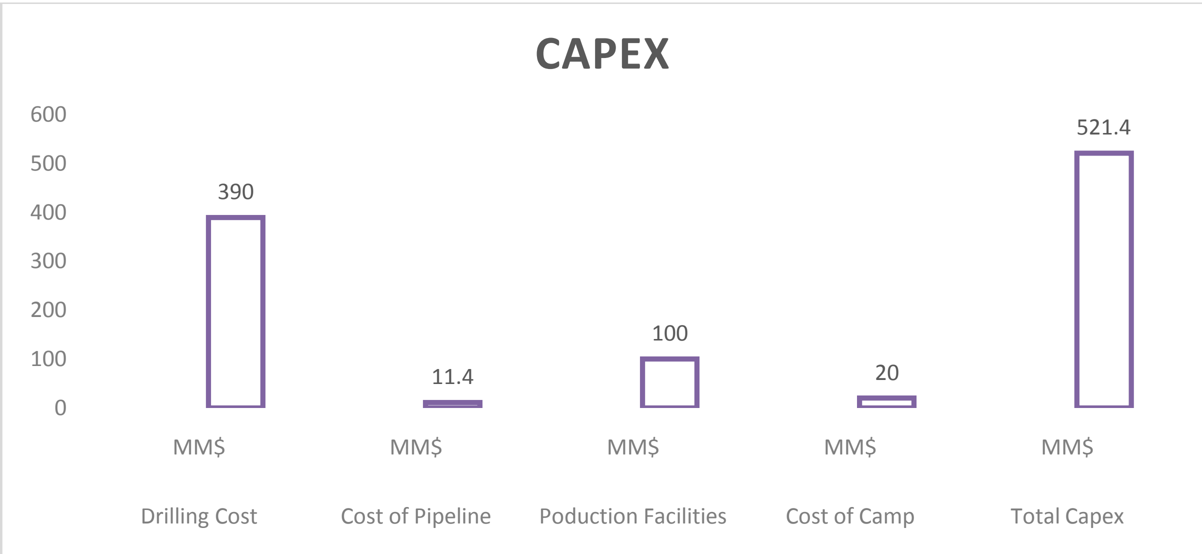

Fig 5: CAPEX

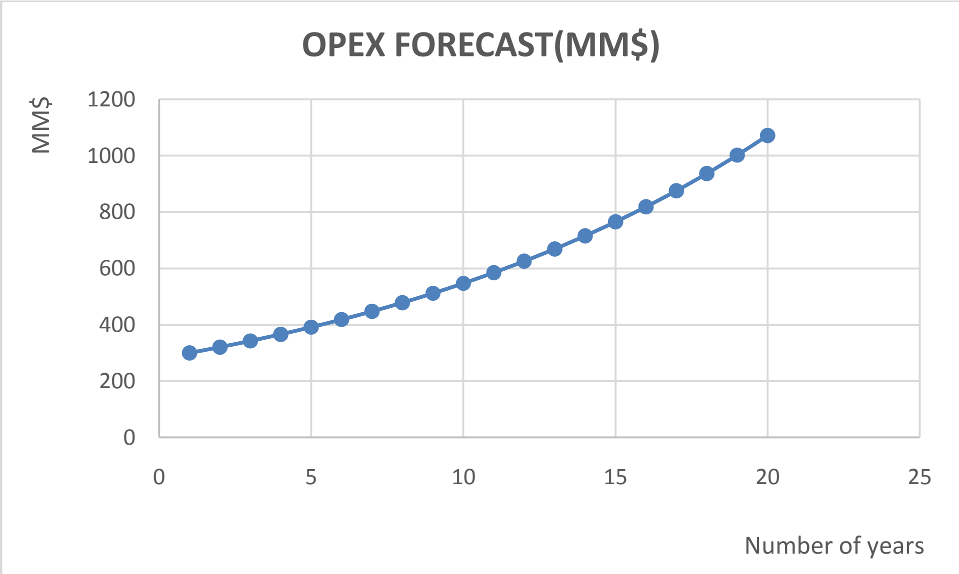

Fig 6 OPEX FORECAST.

The largest single cost element is generally government take, which consists of royalties and taxes. Fig 7, shows the result for the tax and royalty generated.

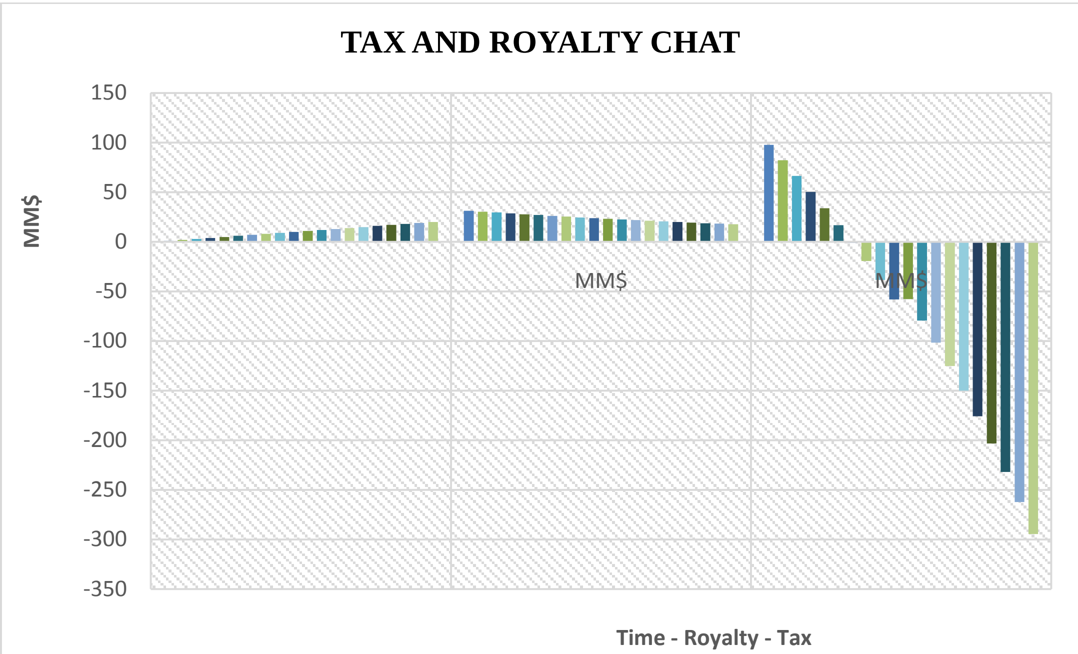

Fig 7: Taxes and Royalties.

3.2GENERATION OF CASH FLOW MODEL

Table, 3 present the cash flow model. It covers the projects entire life, making it possible to evaluate the economic performance of the project.

Table 3:Cash flow model

Year	Gross Revenue	Capex	Depreciation	Opex	Royalty Rate	Royalty	Taxable income	Tax Rate	Tax	Carsh Surplus	Discount Rate	Discont Factor	Present Value	Profitability Indicators
	MM$	MM$	MM$	MM$		MM$	MM$		MM$	MM$			MM$	
0		521.4								-521.4000	10%	1.0000	-521.4000	
1	627.8219		52.1400	300.3079	5.00%	31.3911	243.9829	40%	97.5932	198.5297	10%	0.9091	180.4816	
2	609.1463		52.1400	320.9462	5.00%	30.4573	205.6028	40%	82.2411	175.5017	10%	0.8264	145.0427	
3	591.0262		52.1400	343.0247	5.00%	29.5513	166.3102	40%	66.5241	151.9261	10%	0.7513	114.1444	PBP = 3.937 YEARS
4	573.4452		52.1400	366.6449	5.00%	28.6723	125.9881	40%	50.3952	127.7328	10%	0.6830	87.2433	
5	556.3872		52.1400	391.9155	5.00%	27.8194	84.5123	40%	33.8049	102.8474	10%	0.6209	63.8601	
6	539.8365		52.1400	418.9531	5.00%	26.9918	41.7516	40%	16.7007	77.1910	10%	0.5645	43.5723	
7	523.7782		52.1400	447.8824	5.00%	26.1889	-2.4330	40%	-0.9732	50.6802	10%	0.5132	26.0069	
8	508.1976		52.1400	478.8371	5.00%	25.4099	-48.1894	40%	-19.2757	23.2264	10%	0.4665	10.8353	
9	493.0805		52.1400	511.9606	5.00%	24.6540	-95.6741	40%	-38.2696	-5.2645	10%	0.4241	-2.2326	Economic limit
10	478.4130		52.1400	547.4063	5.00%	23.9207	-145.0539	40%	-58.0216	-34.8923	10%	0.3855	-13.4525	NPV 1 = 149.7866
11	464.1819			585.3387	5.00%	23.2091	-144.3658	40%	-57.7463	-86.6195	10%	0.3505	-30.3596	IRR 1 = 2018.30%
12	450.3741			625.9340	5.00%	22.5187	-198.0786	40%	-79.2314	-118.8472	10%	0.3186	-37.8684	
13	436.9771			669.3812	5.00%	21.8489	-254.2530	40%	-101.7012	-152.5518	10%	0.2897	-44.1888	
14	423.9785			715.8828	5.00%	21.1989	-313.1032	40%	-125.2413	-187.8619	10%	0.2633	-49.4699	
15	411.3666			765.6556	5.00%	20.5683	-374.8573	40%	-149.9429	-224.9144	10%	0.2394	-53.8427	
16	399.1299			818.9324	5.00%	19.9565	-439.7589	40%	-175.9036	-263.8554	10%	0.2176	-57.4226	
17	387.2572			875.9623	5.00%	19.3629	-508.0680	40%	-203.2272	-304.8408	10%	0.1978	-60.3111	
18	375.7377			937.0128	5.00%	18.7869	-580.0620	40%	-232.0248	-348.0372	10%	0.1799	-62.5976	
19	364.5608			1002.3704	5.00%	18.2280	-656.0376	40%	-262.4150	-393.6226	10%	0.1635	-64.3604	
20	353.7164			1072.3422	5.00%	17.6858	-736.3116	40%	-294.5246	-441.7870	10%	0.1486	-65.6688	
														Project Life
	9568.4130		521	######		478.421			########	-2176.8591			-391.9886	NPV 2 : -391.9886

The figures are obtained, generally on an annual basis, by subtracting the cashout (CAPEX, OPEX, Tax and Royalty) from gross revenue to give the net cash flow (cash surplus or cash deficit). Considering the time value of money, those the future cash generated are converted to their present values by incorporating a discount factor.
In order to be able assess whether the project is profitable the present values are summed up to represent the Net Present Value (NPV).

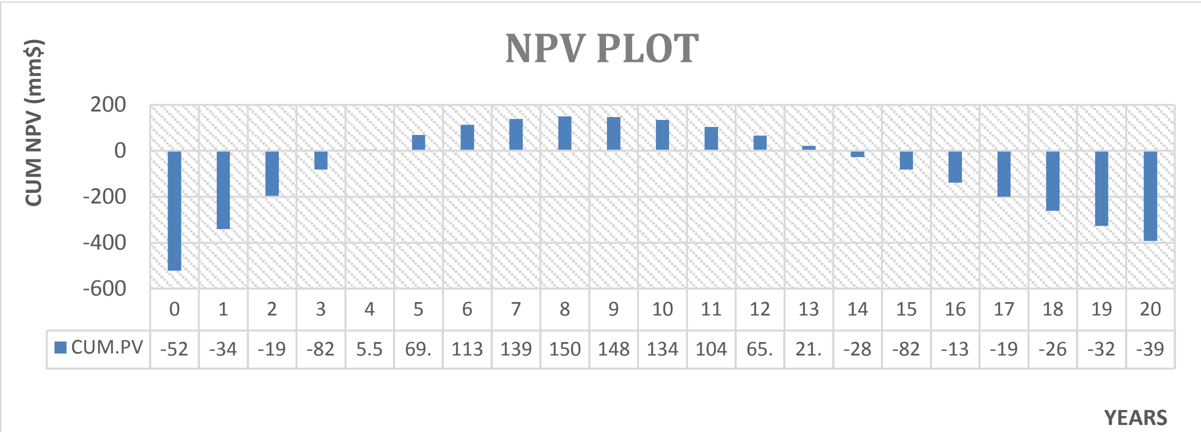

Fig8: Graphical presentation of cash flow

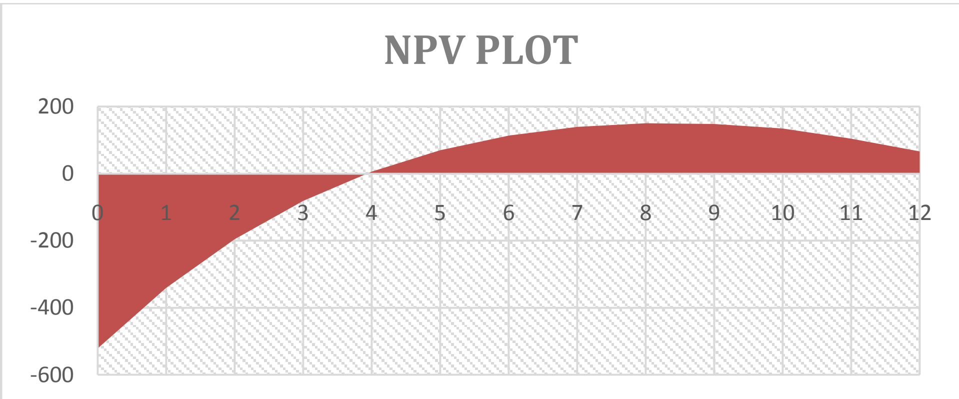

Fig 9:Cum. Disc. Cash flow

The profitability indicators column in table 3, summarizes the results of the most important projects appraisal tools used in assessing the profitability of this projects: Net present value (NPV), internal rate of return (IRR), and the Payback Period (P.B.P).

The plot of cumulative discounted cash flow shows in Fig 9, also illustrates several of the so called profitability indicators. After investing 521.4 MM$ (the depth of the cash sink, or exposure) which will retrieve in total after the payback period of 3.937 years, the project will have earned maximum of 149.787MM$ NPV at

8 (economic limit). The project IRR was determine using “what if analysis” to be 20.183% at economic limit of the project. As a general rule under Tax and Royalty system, the economic limit of production is the rate at which revenue and Royalty plus OPEX are in balance: after that point, production creates a deficit unless the OPEX or the royalty can be reduce [*Shell International Exploration and Production B.V. (2001)*].
From the investment decision rule in table 3, [8], the “the project will be accepted if it net present value is greater than zero”. Now by deciding to accept this investment today the shareholders (Contractors) wealth is going to raiseby 149.787MM$ today, if the projects lasted for 8 years.

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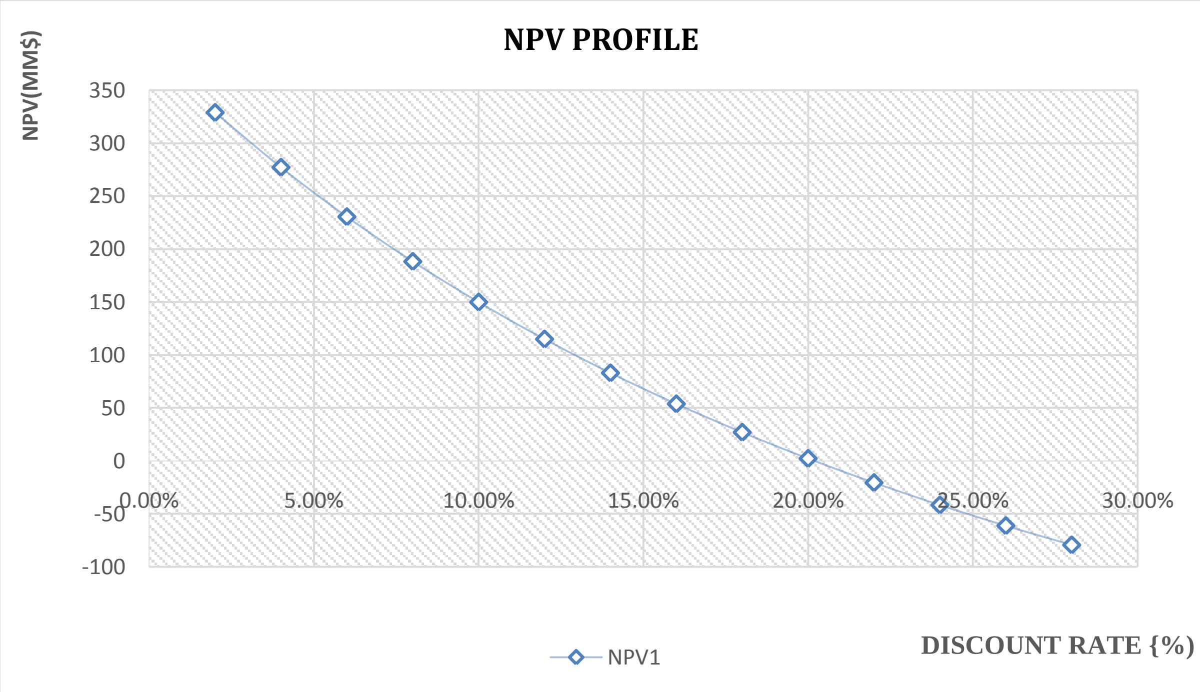

Fig 10: Graphical solution for IRR.

Alternatively, internal rate of return can be graphically demonstrated by plotting NPV against increasing discount rate as shown in Fig 10. As the definition of IRR is “the discount rate that returns a net present value of zero” that is, the point at which the NPV profile cuts zero NPV line. The results of the IRR is approximately equal to the results foundusing “what if analysis” shown in Table 3.

Indicators	Accept	Reject
Net present value	Npv> 0	Npv< 0
Internal rate of return	IRR > r	IRR <r = Discount rate

Table 4: Investment decision rule [8].

From the investment decisions rule in table 4 [8], the project will be accepted if it Internal rate of return is greater than the discount rate. Therefore, when comparing the IRR of the project with the given discount rate (borrowing cost %) the difference of the two is what the projects (Contractor) win.

3.3 SENSITIVITY ANALYSIS

Sensitivity Analysis is the calculating procedure used for prediction of effect of changes of input data on output results of one model. This procedure is often used in investment decision making related with the investment project evaluation under conditions of uncertainty [5].

One-way sensitivity analysis allows a reviewer to assess the impact that changes in a certain parameter will have on the model's conclusions. This is performed by varying the valueof the one concerned input variable in the model by a given amount, while keeping all the other variable parameters at their base values, and examine the impact that the change has on the model's results. This sensitivity analysis has been performed for the various specified ranges of the input variable parameters shown in Table 2and the results are recorded as shown in Table 5indicating the low and high output values of NPV with respect to the base value.

Table 5:

	-20%	-10%	Base case	+10%	+20%
Oil Price	-199.720	-24.967	149.787	324.540	499.293
Qo	-199.731	-24.972	149.787	324.546	499.301
CAPEX	231.814	190.800	149.787	108.773	67.760
Discount Rate	188.139	168.508	149.787	131.919	114.854

The results in Table 5, shows the results for sensitivity analysis carried on NPV, a 10% increase in the base crude oil price represent an increase in NPV from 149.787MM$ to 324.540MM$ and 20% increase results inNPV increase to 499.293MM$. Also decrease in -10% and -20% returned NPV [-24.967MM$ &-199.720MM$].Fig 12: Sensitivity for production rate

When one-way sensitivity is carried on production rate, the results, reveals that an increase in oil production rate by 10% and 20% will increase the field's NPV to 324.546MM$ And499.301MM$. and if there is reduction in crude oil production by 10% and 20%, the NPV for the field will decrease to -24.972MM$ and -199.731MM$ respectively.

Results for the Sensitivity carried onCapex, shows that increase in 10% and 20% of the investment cost reduce NPV from149.787MM$ to 108.773MM$ and 67.760MM$ respectively, whereas the firm will make very good profit if the capex reduces by 10% and 20% yielding NPV of 190.800MM$ and 231.814MM$ respectively.

Also for the Discount rate, NPV varies inversely with the increase in Discount rate, the resultsshow that an increase in Discount rate rate by10% and 20% will reduce NPV to 131.919MM$ and 114.854MM$, whereasreduction of Discount rate by 10% and 20%causes an increase in NPV to 168.508MM$ and 188.139MM$ respectively.

3.4 TORNADO DIAGRAM

Fig 16: Tornado diagram

Figure 16,are arranged downward from largest swing down to smallest swing, and presented as tornado charts for the NPV, we note that the input variables associated with maximum swing which have much impact on the field's NPV are oil production rate and oil price. This is followed by Capex and Discount rate. Tornado chart usually gives the oil firm a snapchat of the variable(s) to concentrate on more, so as to minimize the risk inherent in the project.Then it can be seen that the oil production rate and oil price are the most influential single input variables while the CAPEX and Discount rate are the factor with least effects on the NPV.

IV. CONCLUSION AND RECOMMENDATIONS

It can be concluded that a map showing the oil and gas producing states in Nigeria was produce using GIS approach and also an automated cash flow model was successfully developed using an excel spreadsheet which provides the investors with opportunity of making decision using NPV, IRR and Payback Period.The study revealed that the oil and gas field reaches it economic limit at 8 years with NPV, IRR and Payback period of 149.787MM$, 20.183%, 3.937 years. This indicates that the project is viable under the base scenario since the value of NPV is greater than zero. And the IRR for the project is 20.183% which is also greater than the discount rate (10%).

When the oil and gas field was subjected to further one-way sensitivity analysis, the results from the Tornado plot revealed that oil production rate and oil price have the greatest impacts on the field NPV followed by CAPEX and Discount Rate.

The study recommends re-assessment of impact of petroleum fiscal system on the investors and contractors for further research.

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