Risks to petroleum production and processing assets in compromised economic environments

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Abstract:
Changes in climatic and weather patterns, occurrence of natural and industrial disasters and wars have become common occurrences. The Impact of these events have affected the revenues, debt profiles and economic prospects of nations, investments, investors and the population directly and indirectly. These situations have also put to test the leadership capacities at the national, corporate and community levels with some emerging with growth and innovations , others maintaining the status quo and in some cases, a drastic decline is experienced in revenues, living conditions and quality of life depending on the decisions and actions taken.
Production of petroleum and processing assets are designed to overcome (withstand) severe weather events, earthquakes and predictable adverse conditions, however severe economic downturns have forced human assets within communities into desperate actions to restore individual and collective economic status quo, which potentially compromise the sustainability, revenues and economic contribution of high capital investments in the petroleum industry located in those communities . These actions have been demonstrated in different forms such as, restiveness, vandalism, product and equipment thefts and in the extreme , breakdown of security, law and order with consequences of increase in hazardous and unsafe working conditions and fatal accidents (disastrous incidents). A stakeholders universe shows the extent of dependence by a desperate group of multidisciplinary unemployed youth of various communities on artisanal refining and marketing of the products for economic survival while neglecting the sustainability of the crude oil pipelines investments by the registered oil companies holding the mining licenses and operating the various fields. The integrity of the pipelines are compromised and the actions of the youth and their sponsors cause serious environmental effect on land, water and air, and the health of the rest of the population is challenged as well as the health management system .
This paper will present the results of questionnaire survey to understand their motivations and impact on the petroleum industry with respect to investments, major safety incidents that have occurred and actions taken in some Nigerian petroleum production and processing facilities to mitigate pipeline asset vandalization, loss of revenues and investments from misplaced or stolen crude oil productions and marketable products . It will also look at how regulatory systems elsewhere are applied and provide lessons for other operating regimes in other parts of the world as well as broad lessons for the regulatory systems.

Key words: sustainability, hazards, investments

Core theme : human factors

Introductions

The performance of Governments and rulers are measured by the welfare and wellbeing of the citizens among other metrics. In the past, changes were through revolutions, rebellions and coup d'tat. With democratic institutions the citizens have the right to vote out non-performing leaders rather than through violence and rebellions. Unfortunately, many countries are led by dictatorships that cared less about the progress in infrastructural development, power supplies, education, health and welfare of the citizens. With decades of neglect, anarchy becomes the order of the day where without an economic safety net, rule of law is undermined, and people become outlaws and exploit every means and opportunity to survive and provide the basic necessities of life for their families. The destruction of occupations due to degradation and pollution of rivers and farmlands without adequate compensation could also be reason for peaceful or uncivil protests.

Nations earn foreign exchange from exports which could be from natural resources (raw or semi processed or completely processed into finished products), manufactured products from imported raw materials, services or re-exports after value addition to imports, and also from migrant workers and diaspora remittances . When the value of imports exceed the value of exports, a trade deficit arises that will accumulate if not corrected, which will lead to debt. Assets can be sold and loans can be taken to cover budget deficits, develop infrastructures and projects that have significant multiplier effect on the economy and growth of the gross domestic product (GDP). It is observed that the export of unfinished raw materials earn low income compared to processing of the materials into finished products, with higher growth and multiplier effect on the economy through the development of skills and craftsmanship for the sustenance of small scale enterprises . Countries that depend mostly on sale of natural resources tend to be wasteful and stagnated in their development while those that earn their revenues from processing the imported raw materials into marketable finished products are more industrialised, innovative and prosperous.

Disasters from climate change, earthquakes, geopolitics, wars, leadership with wrong ideology and direction, poor governance structures, lack of transparency and competitiveness and unbridled corruption among others tend to accelerate the decline of the wealth of nations. Wealthy nations with high level of human capacity development, that embraced the adoption of leadership accountability, technology and innovation tend to overcome the destructive forces of nature, pandemics and other challenges better than others. Collective imposition of sanctions against nation(s) are also intended to cause economic decline as target revenues dwindle creating opportunities for cooperative actions or countermeasures for state preservation. Current challenges on rise in global temperatures and its impact on weather patterns, have also affected the energy security of countries and the revenues of fossil fuel producers. Due to some high-impact catastrophic incidents and accidents in nuclear power plants (Chernobyl, Fukushima and others) and civil protests that followed have slowed down development of nuclear power plants in preference to alternative cleaner sources of fuel. Germany and Japan took drastic actions shutting down several nuclear power plants and this could further affect the energy security of the affected countries and in consequence the economic performance. This also provides opportunities for policy changes for or against carbon neutral agenda or other economically sustainable actions for state preservation. With Nigeria specifically, while income from oil and gas resources operated by international oil companies (IOCs) and local independent oil producers provided revenues in foreign exchange, the "wealth from other resources that were once the mainstay of the economy such as coal, groundnuts , cashew nuts, cocoa, cotton,

livestock, palm oil, rubber, tin, wood – were allowed to decline in importance year – on – year since the oil boom of the 1970s." Adewole Maja-Pearce, 2005. This was followed by systematic destruction of productive capacity of assets and gradually increasing security threats. The climate for free and fair economic activities is usually affected when there is a major resistance due to unacceptable conditions environmentally, economically or politically or denial of human and civil rights.

Literature survey

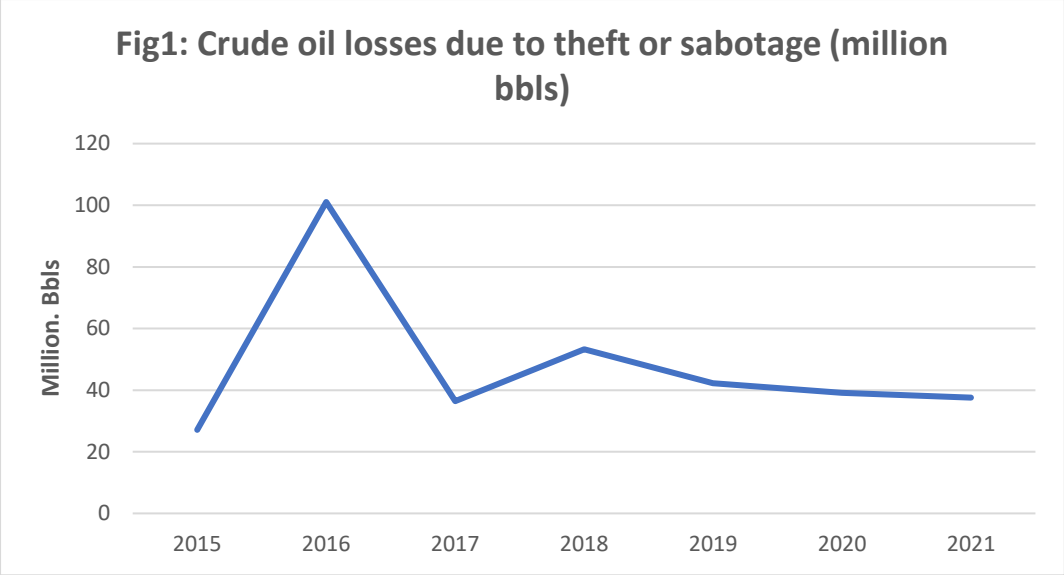
There are different uses of pipelines, some for conveying natural gas, hazardous products, crude oil, marketable oil products and chemicals, water etc , some with right of way on farm lands, jungles with dense canopy and some under the sea in fishing regions. Each of them require appropriate regulations of the sovereign nation of transit of the physical pipeline location. Theft of petroleum products and crude oil from pipelines has been reported extensively in Nigeria, South (S) America and South Eastern (SE) Europe. These pipelines are a target for criminals, vandals and terrorists in S. America and SE Europe exceptions being Nigeria where the reasons are criminal, socio-economic and political. The April 2022 performance report of the European pipeline, safety and environmental monitoring organisation covering 1971 to 2020 indicated that pipeline theft attempts were one incident per year or less at the beginning of the decade, however this has increased to 147 in 2015 across the European continent with 36,000km of cross country oil pipelines and concentrated in South Eastern Europe. In Mexico, reported volumes of stolen crude oil / products were as high as 58,200 bbls/d in 2018 (Arantza et al). Nigeria Extractive Industry Transparency Initiative (NEITI) oil and gas report of 2020 indicated an average loss of 15.12% of fiscalised production due to theft or sabotage, with maximum of 32.49% and minimum of 0.36% among 22 companies made up of international oil companies (IOCs) and indigenous oil and gas operators that submitted extractive industry transparency reports and feedbacks. It is important to note that all the domestic refineries were not in operation during this period. Analysis of the Department of petroleum resources (DPR) published crude oil losses on the refineries crude oil supply pipelines from 2010 to 2019 showed an annual average of 1.121 million barrels of crude oil, or 3,310 bbls per day. This was because the refineries were operating at 10% to 20% of installed capacity due to technical, commercial and other reasons. More losses would have been suffered with higher capacity utilisations. Under this situation, the result of investments to achieve growth or operational excellence practices were suppressed as they would not be shown in the bottom line.

These thefts involved drilling through the pipeline to install a small bore valved connection. In Mexico, criminal gangs switch from thuggery and exportation of drugs to stealing of oil products and crude oil from PEMEX pipelines. These groups donate part of the proceeds to communities- in- need within which they operate, in various forms of social services to gain support and sympathy . Arantza, A.B and Spencer C (2021) used crime script analysis to reveal the roles of the members of the criminal gangs and the support they received from technical specialists, security services, businesses and communities. This finding from crime script has similarities with the activities of crude oil and oil product thieves and artisanal crude oil refiners in Nigeria. However, crime script does not reveal the motivation for the crime and the socioeconomic conditions that drive and support the crime.

Nigeria's economy boomed during the 1970s, transforming the country to the position of 30th richest country in the world. With unstable oil prices, political instability and compromised economic management, the fortunes of the country began to slide for the worst, not only in oil exploration, production and service sectors, but affected other linked and related manufacturing activities some of whom relocated to neighbouring countries that had more attractive business friendly policies. In the Niger Delta region, environmental oil pollution and gas flares caused fertile agricultural farmlands to waste making farmers helpless while fishermen found fishing, no longer a sustainable occupation with fishing territories devastated with pollution. Ageing Crude oil pipelines built in the 60s and 70s are prone to mechanical and corrosion–related failures and are a cause of concern for operators and regulators on the state of their integrity. Good integrity management and maintenance systems have played a role in the safe and reliable operations of these pipelines. Accidental third party interference could cause damage such as while undertaking digging, excavating and earth moving activities which could cause spillage incidents. However, this is mitigated by markings on the right of way, surveillance, permits, and regular communication with host communities.

Accidents occur from operational equipment failures and human errors, causing spills. Drilling fluids and cuttings when improperly treated and disposed are also causes of environmental damage. The oil industry is highly capital intensive, highly regulated, best-in-class technology and special skilled activities that are not labor intensive except when major projects are being executed, hence host communities participation is low at project completion. At this phase, there is usually restiveness as the employment opportunities are not fairly spread . As facilities age, oil spills increase causing pollution that destroys the ecosystem on land and the waterways. When detected late or a misunderstanding followed on the root cause of the spill, the Operators actions in arresting the leakage, mobilising cleaning activities and other interventions are sources of controversy. The accumulated effect of poorly or uncleaned spills is low yield for peasant farmers and fishermen as occupations are destroyed. The trend is gradual rise in cost of living in these city states and rural communities beyond the means of the people, increase in poverty rates and eventually increase in rural-urban migration to seek a means of survival. Due to benefits of land ownership, oil well locations are a reason for inter community claims, litigations, counter claims, crisis and violent fights that could claim many lives. These events increased hostility towards oil and gas production activities. Exploitation and monetisation of gas was slow compared to oil, as large scale flaring was the main method of disposal with its attendant air pollution .

In the 2000s, the Niger delta region where most of the reserves were found felt uncomfortable with the beneficial ownership of several oil blocks allocated. "It is observed that majority of oil companies in Nigeria exhibit complex structures that shield the identity of their real owners. Identifying the natural persons behind the companies which is the objective of beneficial ownership disclosure is still challenging" (NEITI 2020 oil and gas industry report).

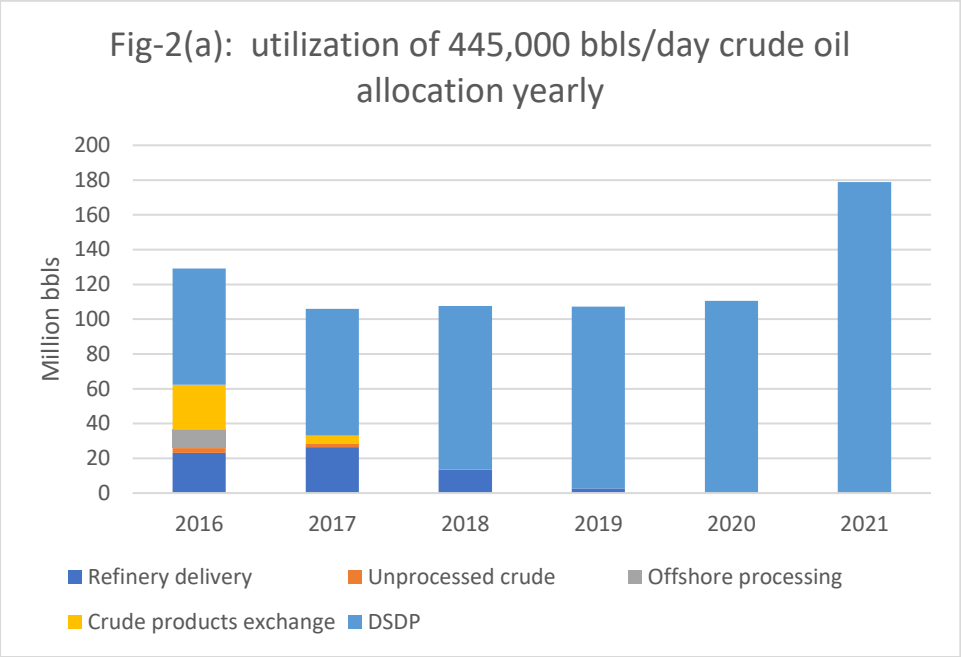


Source: NEITI Oil and gas reports

Other reasons were objections to the revenue allocation (sharing) formula with respect to derivation on mining which had been contentious and over the years, progressed from 1.5% to 2% in 1985 and 13% Federal allocation by 1999 from the oil revenues; and constitutional concentration of power at the federal level at the expense of the states and local councils that were closer to the people and their needs. Some of the IOCs handled community protests in such a manner that visited excessive violent force by sympathetic State security forces on those communities. This led to more civil protests and agitations, numerous non government organisations (NGOs) sprang up in defence of human rights and environmental issues, formation of several youth movements that ultimately transformed into militant groups seeking protection of one territory or the other within the Niger Delta region with some of those structures being used in party politics and elections. Damage to oil facilities. kidnapping of oil workers and prominent non-oil workers for ransom in the region and in other parts of Nigeria increased and became rampant during this period. Crude oil theft and sale became another source of revenue for militant organisations using the proceeds to purchase arms for fighting among themselves or attacking oil and gas facilities. Artisanal crude oil refining products were used to fuel marine boats for piracy operations, supply logistics and running of the militants camps. With impaired security in the focused-operational areas, discovery of additional reserves, development and production began to decline rapidly particularly in the on-shore block allocations. Most of the IOCs moved new investments into deep offshore acreages where the fiscal conditions were more attractive at the time and exploration and exploitation projects could be safely and securely carried out with less disruption or interference. “Investors always take into consideration the level of shield afforded and deterring factors in the host country and avoid loss of assets, skilled labor and return on investments (Kolstad et al 2002, and Busse et al , 2007). A 2021 study by Danguma I, also found that sectors such as banking, construction, oil and gas, manufacturing, and telecommunication in Nigeria were adversely affected by political risk factors (terrorism and corruption, political violence and religious tensions). Faced with very low crude oil production that could hardly meet the revenue needs of the government, a presidential amnesty (pardon) was granted to the militants in June 2009 with conditions. The amnesty program was to disarm, educate and rehabilitate (with monthly stipend) the militants in the Niger Delta region. The program achieved 40% increase in crude oil production from the level that would have been achieved in the absence of the policy (WD Walls 2020). With limited success of the program, those that were not properly rehabilitated went back to resume or continue with illegal artisanal crude oil refining and oil theft, trades learnt during the militancy period; and those engaged in this trade increased with the number of unemployed graduates, school leaving youths and economic migrants from the north east (NE), north west (NW) and north central (NC) regions of Nigeria who were displaced due to terrorist activities, deadly farmer – herdsmen clashes and could not get jobs even at the minimum wage of N20,000 - N30,000/ month ($1.57 - 2.35/day). “There was a ready market for the oil products in view of the attractive price differential between artisanal crude oil refining products and the imported kerosene and diesel products’ pump price at the fuel stations” (Akani, E.C 2021).

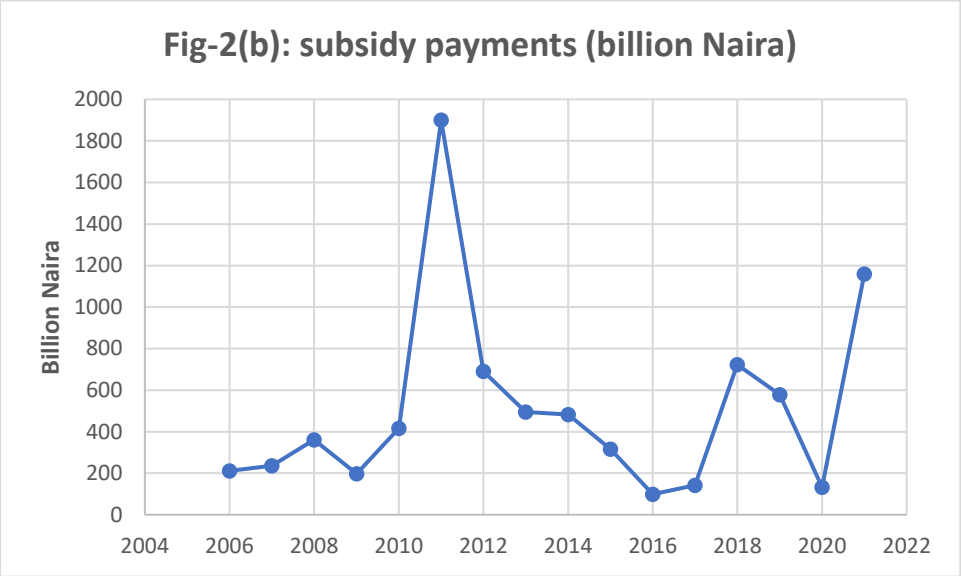
During this period the performance of government owned refineries deteriorated due to unusual delays in carrying out due turnaround maintenance (TAM), and when TAM was eventually done it was realised that pipeline losses on the crude oil supply lines for Bonny light and Escravos crude oils were far higher than margins realisable in operating the refineries. High level of thefts also occurred on the IOC’s crude oil export trunk lines as well as the lines from individual wells flowing to stations manifolds for processing. This led to hard decisions on cost-effective and best utilisation options on the 445,000 bpsd allocation for the domestic refining business, while meeting the domestic petroleum products supply of premium motor spirit (PMS) that was under a subsidy regime.

Fig-2a: utilization of 445,000 bbls/ day domestic crude oil allocation yearly



Source: NEITI 2019 oil and gas report; OPEC Annual Statistical Bulletin 2021, 56th Edition

Local crude oil refining activities were disrupted which eventually ended up in total importation of petroleum products between 2019-2021 using a model of direct sale of crude oil and direct purchase of petroleum product (DSDP) in the short term that led to complete shutdown of the national refining capacity. "The petroleum products delivered at designated Nigerian sale port(s) shall be equivalent in value to the crude oil received by the DSDP company subject to general terms and conditions" (NNPC ITT 2021-2022). The long term fuel supply security is pegged on the completion of construction, commissioning , operations and maintenance of the 650,000 bpsd Dangote refinery, a private refinery initiative with minority equity participation by Nigerian National Petroleum Corporation (NNPC). These decisions resulted in significant decline in productivity in the downstream, degradation of poorly mothballed assets requiring rehabilitation programs, disruption of the refineries supply chains and loss of local businesses that support refining activities; missed opportunities to operate and take advantage of windows with very high refining margins . In combination with upstream and downstream underinvestment over some time horizon, peaking oil fields, crude oil theft and changes in production arrangements among others, crude oil production fell drastically and OPEC production quotas could not be met. There were consequences on the economy with respect to revenue, forex exchange rates, devaluation of the local currency, inflation and increase in sovereign debt, part of which was utilised to pay for unsustainable fuel consumption subsidy that was very significant compared to revenue. "At the global level, international organisations and policy makers have raised concerns regarding how well-targeted energy subsidies have been, especially with regards to protecting the poor segment of the society. Those who believe that energy subsidies have outlived their usefulness have called for its abolition in order to free up fiscal resources for economic development (Babatunde S. Omotosho, 2019)". Also Umar et al (2013) and Siddig et al (2014) noted that Nigeria's subsidy regime distorts fiscal planning, encourages inefficient consumption and increases inequality as richer households benefit more. The world bank group urges, "so we encourage that when there is need for subsidy, either for food or for fuel, that it should be carefully targeted at those most in need of it".

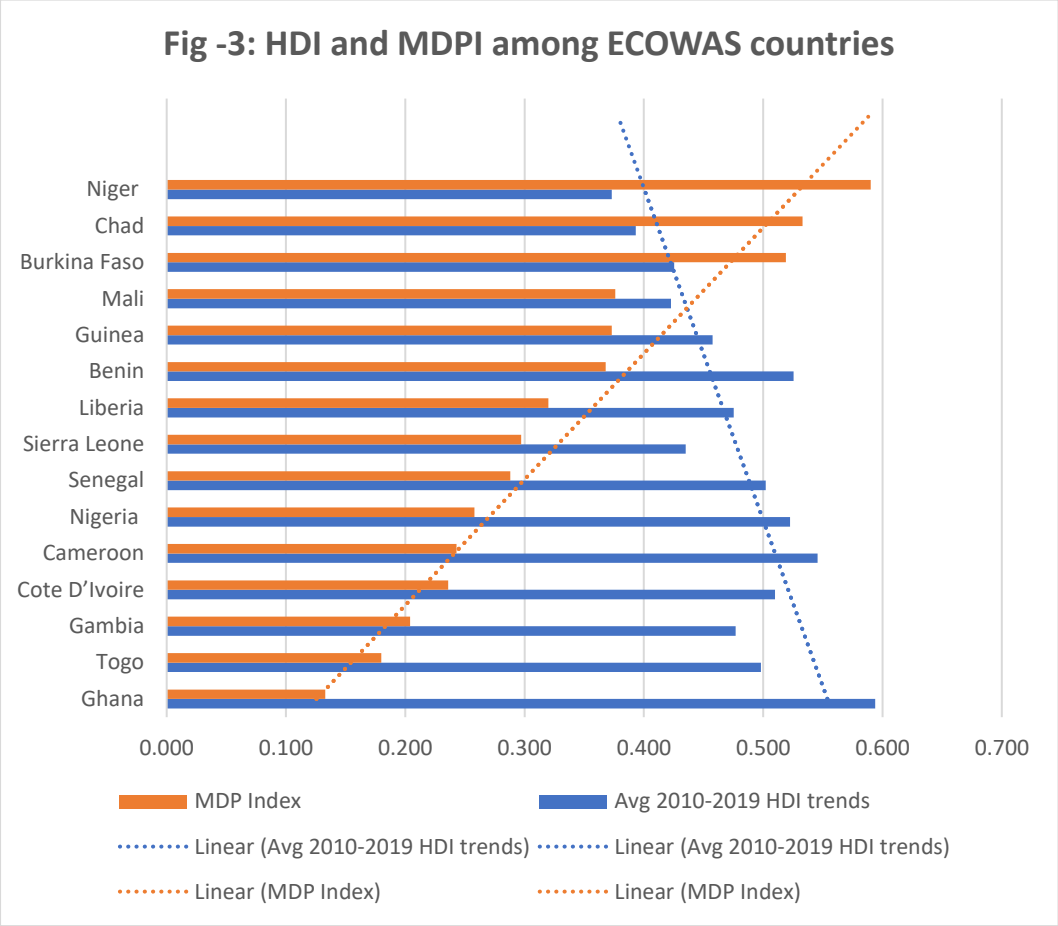


Source: CBN , NEITI and Ministry of Finance sources

After the failure in the 1930s (Great Depression) of the classical economic system, Keynesian economists have advocated the use of public expenditures to promote growth and development and correct short term distortions in the economy, provide basic services such as health, education and others to impact on the wellbeing of the citizens and business environment for the private sector. Neoclassical models support the view that government spending only affects economic growth in the short run. Ebong et al (2016) in their study established that capital expenditures positively affect economic growth in Nigeria. This could be due to the fact that most capital expenditures are on productive projects like roads, schools, hospitals, airports among others which have higher social benefits and longer paybacks. On the other hand, recurrent expenditure is found to have significant negative impact on economic growth of Nigeria due to debt interest payments on previous borrowing and fuel subsidies. (Aluthge et al, 2021).

Dissatisfied with gross domestic product (GDP) or gross national product (GNP) per capita alone as the measure of economic development, some economists have used social indicators based on basic needs such as food, housing, health, education , water supply and sanitation. Since 1990, United Nations development program (UNDP) annually has been reporting on human development index (HDI) which is a composite of three development indices on living a long and healthy life, being educated and having a good standard of living to show how growth in GNP translates or does not translate into human development in the society. The focus is that human development should be about how development enlarges choices available to the people of the country (Afemikhe, SSO, 2015). For economic development to occur, the rate of increase in per capita real income or output should be higher than the growth rate of the population. The population growth rate of Nigeria was 2.5% between 2000-2010 and 2010-2020. Hence technically there will be no development when the GDP per capita is below 2.5%, which will mean economic retardation. Graduate unemployment is very high and unemployment-induced poverty tends to increase the crime rate and violence in the country (Majid M, 2013). Afemikhe SSO (2015 page 189) in “Hope Rekindled” pointed to the trend in Nigeria that “Most unemployed youth resort to crime such as robbery, kidnapping for ransom, internet fraud, and other forms of fraudulent activities”. The educational system that had misalignment with the labor market was graduating more youths than the economy could provide suitable jobs for. Government investment policies were not investor-friendly and major private sector investments were limited. Unfortunately there is no national social safety net for the unemployed except dependence on family members and relations for support. In the UNDP human development report 2020, two additional dimensions were added to the HDI to capture the current concerns on sustainability (economic and social) and environmental degradation to capture the excessive pressure on the planet’s climate and ecosystem. It is recognised that the high quality of life enjoyed in a country with high carbon emissions as in the case of developed countries could be at the expense of other countries with low carbon emissions as in the case of underdeveloped countries. While HDI is a view of development measurement that put people at the centre, PHDI captures the planetary pressures from development using a derived adjustment factor, based on CO2 emissions per capita and material footprint per capita. Multidimensional poverty index (MDPI) measures human development with a spotlight on poverty.

Fig-3: HDI and MDPI among ECOWAS countries



Source: UNDP human development report 2020

Benchmarking performance against successful peers helps and enables organisations and nations to make progressive plans and targets. It is apparent with Fig-3 that countries with high MDPIs and low HDI in the ECOWAS region have populations with tendency to migrate to low MDPI countries for temporary and permanent pastoral cattle grazing land. It therefore provides some insight into the high level of insecurity and fighting between herdsmen and farmers in countries like Nigeria, which adopted an open border policy in the last few years.

Misery index was created by the economist Arthur Olin in the 60s for the USA economy. The index is calculated by adding the unemployment rate, the inflation and the lending rate minus percentage change of the GDP. This concept has been expanded by economist Steve Hanke to include 156 countries to show best and worst countries to live in from an economic perspective . This is another tool in addition to HDI to compare the development of countries, and the ranking of Nigeria has been sliding for the worse from 2019 to 2021.

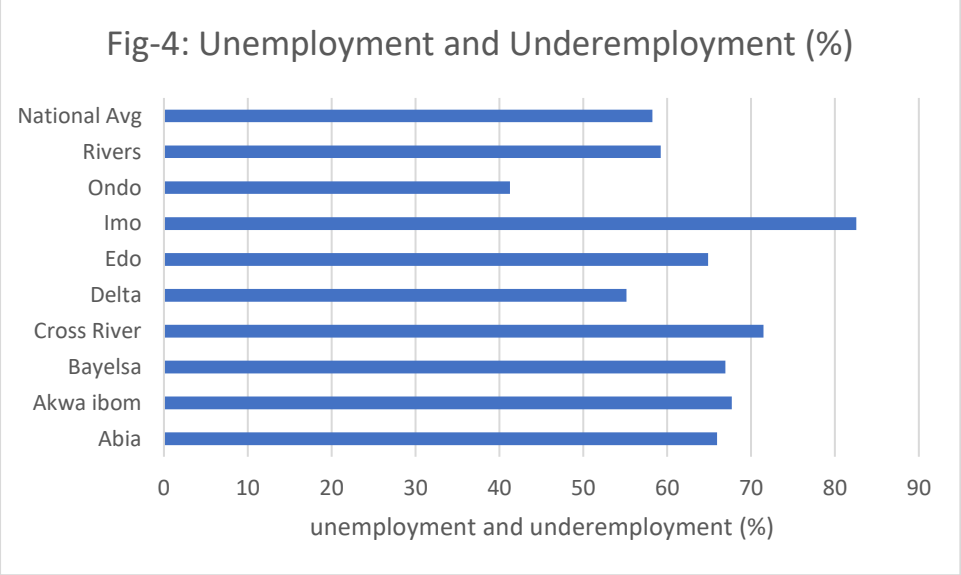
Institutions and governance

There has always been responsible actions by the government since the pre-independence period to address issues concerning the Niger Delta. These include declaration of the area as "Special" by the Willinks Commission of 1958 and the set up of the Niger Delta Development Board in 1959, the set up of the Niger Delta Basin Development Area in 1976, the special fund for oil producing areas by a revenue act in 1981, the approval of 1.5% for the Presidential Task Force for the development of oil producing areas, the Oil Mineral Producing Areas Development Commission (OMPADEC) with 3% derivation revenue allocation in 1992, which was raised to 13% in 2000 and the establishment of the Niger Delta Development Commission (NDDC) specifically to design and implement projects to accelerate improvement of the worsening social and environmental conditions of the area. NDDC is funded from a mandatory levy based on 3% of the annual budgets of oil and gas producing companies in Nigeria. The dependence of the 3% levy on oil and gas company budgets means it is exposed to risks of fluctuations in the prices of oil and gas in the international markets, OPEC production quotas and assigned/ actual companies' production figures, availability and producibility of the assets, foreign exchange rates to the local currency, losses due to sabotage and theft, deferred productions due to force majeure declarations among others. These lists of uncertainties are not familiar to the stakeholders, hence is a source of suspicion and accusations of non-compliance with expectations based on the

budget plan and the actual mandatory 3% levy payments. It also could be a cause of indebtedness if NDDC made commitments based on the initial budget plan projection figures instead of the signed off and closed annual approved budgets. Lack of focus on the mandate has been reported in some years in handling of the funds. There is need for strengthening the anti-corruption, transparency and whistle blower practices with stakeholders feedbacks on community projects and the executing contractors. Prompt payment of completed milestones signed off and closed out contracts will also improve the credibility of the contracting processes and cost of executing projects.

The oil companies also carry out non-mandatory voluntary corporate social responsibility activities involving small project expenditures in host communities and footprints all over the country for roads, boreholes, healthcare centres, scholarships, skill acquisition, agricultural support schemes. In 2008 a Ministry of Niger Delta affairs was also created. Other oil industry initiatives are the incremental domestication of oil and gas EPC project workscopes, equipment supplies and services (local content) aimed at developing local capacities. Nigerian local Content Development and Management Board (NCDMB) was set up to manage the local content of major oil and gas projects workscope and the industrial and services provision capacity development of the local companies and is funded from a mandatory 1% tax levy on all contracts in the upstream sector of the oil industry. As shown in fig-4, there are 7 out of the 9 NDDC states with unemployment and underemployment rates above the national average of 58.2%

Fig-4: Unemployment and Underemployment (%)



Source: Budgit.com state of states 2021

Pipeline Protection

Pipeline losses can occur due to compromised integrity of the pipelines from erosion, corrosion, accidental damage or wilful attempt to steal from the pipeline by vandals and economic criminals. Uncontrolled losses from pipelines can start fires and explosions capable of destroying lives and properties in the vicinity. Preventive measures adopted by companies and operators of the pipelines include surveillance by national and state security, host community vigilantes and company security. Other measures include non-flowing water- pressured lines, pressuring of lines with condensate (if available), use of helicopters and drones for surveillance. In addition, technical indicators such as pressure drop, leak location control system, input-output accounting are used to confirm the occurrence of a loss incidence. Proactive measures include engagement with stakeholders such as the communities, unemployed youth training programs involving acquisition of technical skills, farming (agricultural), computer competency training, community development programs and projects etc. Frequent security interventions and operations to destroy active cells of pipelines -oil -theft is a continuous activity. Between 2015 to 2019, it was reported that 2,287 active sites were destroyed by the Nigerian Navy (the Guardian Nigeria newspaper, 22/5/20), and is a continuous activity of the security forces. It is also reported that over 100 fatalities occurred from a fire incidence at a site known for artisanal refining activities in Ohaji-Egbema in Imo state and another 9 fatalities in Owaza, Abia state also from an area known for artisanal crude oil refining activities (BBC news report, 27/4/22). Unfortunately, all these measures and costs have not fully yielded the desired results of protecting the pipelines from loss of content. Is there any form of cooperation in these repetitive actions?. Robert J Amman, 2005 , stated in his Nobel prize lecture on war and peace that, “A person’s behaviour is rational if it is in his best interests, given his information … and what are the incentives for these people that will lead to economic war on the state revenues (stealing crude oil) and what are the incentives that can be built that would prevent sabotage of these oil pipelines? Perhaps, Lessons can be drawn from game theorems on punishment, cooperation and discount rates (personal and subjective); …if the discount rates are too high, then the players are more interested in the present than in the future, and the

one-time coup (strike) now may more than make up for losses in the sequel. The Perfect - Folk -theorem further states that the cooperative outcomes of game G coincide with the perfect equilibrium outcomes of its super games G (future); that is, repetition acts as an enforcement mechanism, therefore, it makes cooperation achievable when it is not achievable in the one-shot game". At the Public-Private dialogue session on oil theft and artisanal modular refineries organised by the Lagos Chamber of Commerce and Industry on June 30, 2022 in Lagos, the Navy represented by a spokesperson, stating that "crude oil theft is one of the major maritime security challenges. The theft is associated with pipelines vandalism, illegal oil bunkering, that illegal oil activities thrive because of disloyal services of retired oil workers as well as connivance of some security and some surveillance contractors who have good knowledge of the oil pipeline network. Other factors include poverty, high unemployment rate, which leads to youth restiveness and also connivance with some compromised communities and youth leaders in the affected areas, a growing demand of locally refined products due to its comparatively low cost and complexities on the part of security agencies." The sophistication of tools used to illegally access pipelines products particularly crude oil and its disposal to artisanal refiners or for export indicates that "the influencing factors and the players may be beyond the host communities and local or state politics, and more national, multinational or global in coloration (Balouga,J 2009)." The situation is summarised below in Table-1:

Table-1

Drivers	**Regulation**	**Stakeholders**	**Technology**
Systematic failures in national politics to address high unemployment and socio-economic problems. Failed institutions, failed commitments on gas flares and remediation of polluted lands, farms and streams leading to loss of farming and fishing occupations in the remote villages	Laws, Acts, Regulations, Directives are in place but also exist are opportunistic and compromised enforcement under political and economic considerations	Existence of strong resistance from multiple interest groups sustain activities, forming barrier against successful enforcement of regulations	Low capital cost in acquisition and processing equipment and transportation of products with processes that do not meet the Regulatory requirements on HSE and product quality. The regulator has specifications for modular refineries of 100b/d to 10,000b/d , capital cost is however high

The National Oil Spill Detection And Response Agency (NOSDRA) and department of petroleum resources (DPR) reported that between 2010 and 2019, over 6,579 oil spills occurred during petroleum production activities in Nigeria. The low level of wages of public services personnel and delay in its payment, display of unmerited wealth by privileged few within the stakeholders create incentives for resistance to law enforcement by security operatives.

In the activities shown below on artisanal crude oil refining in Table-2 , those that require permits from regulators are in (Red), with changes in legislation these can change to acceptable practices/ trades (Yellow), and green marked activities are within the law with proper licences and permits.

Table-2

Local Purchase of crude oil	**Transportation of purchased crude oil**	**Artisanal - Modular refinery processing of crude oil**	**Transportation of on-specification oil products**	**Marketing & use of on-specification oil products**	**Ar length support services**
NOW	NOW	NOW	Now	Now	Now
FUTURE	FUTURE	FUTURE	Future	Future	Future

The Businessday newspaper of June 16, 2020 reported that government was initiating a process to clean up the artisanal refining practice in Nigeria and facilitate its regulation and integration into the country's petroleum value chain. What is lacking is demonstration of transparency in purchase of crude oil and reliable equipment and processes to meet quality and HSE requirements, and registration as accountable tax payer. These facilities close the gap for diesel which is in high demand for domestic and industrial power generation due to the high cost of imports (as well as scarcity of foreign exchange) and

frequent shutdown of the local refineries. In addition, no major refineries expansion or additional capacity has been initiated by the national oil company except the 650,000 bpsd Dangote refinery which is a private initiative and few private modular refineries of 5,000bpsd (waltersmith and NCDMB), 10,000 bpsd (OPAC) and publicly quoted 11,000 bpsd (NDPR). Operations of OPAC has been constrained due to lack of crude oil, while Waltersmith and NDPR are also upstream oil producing companies.

The use of crime scripting methodology (Arantza et al, 2021) identified the following interest groups that would benefit from artisanal refining activities :

- The artisanal operators: the Nigerian Midstream and Downstream Regulatory Commission (NMDRC) does not give permits for construction of unlicensed artisanal facilities for batch distillation of crude oil. The facilities are small in capacities at the low end of modular refineries capacity (100 bpsd – 10,000bpsd, DPR 2018 Annual Report), that can be licensed on the condition that process designs, codes, specifications and construction drawings, plot plan area that meets safety requirements are submitted for approval and the payment of license fees. The number of operating facilities spread through the length and breadth of the oil producing states with isolated installations along the Warri – Kaduna crude oil pipeline right of way. The numbers have drastically declined from interventions of law enforcement agents.
- Transportation: there is high dependence on manually propelled boats, speed boats, tugs and uncertified barges for movement of raw materials and distribution of products on rivers and trucks on land. Pirate attacks and kidnappings are common, necessitating the need for security escorts
- Marketing: demand for products is high. The price differential between imports and local supplies for diesel was as high as N100/ltr ($0.28/ltr)
- Service providers: existing cellular network communication, USSD facility for funds transfers, and exchange of intelligent information between operators and informants that gather activities on target flow lines and oil company production and maintenance programs. Embedded intelligence security assets also use the networks.
- Legal Contracts: transactional contracts and agreements covering payments and service guarantees in the value chain are common.
- Financial Advisers: funds are required, sometimes considerable, to carry out activities across the value chain
- Security Consultants: the support and patronage of security consultants is critical. Every location that is active is known and closely monitored by the embedded security and intelligence agents.
- Medical Consultants: medical support is required to attend to workers injuries and the health of Community members who may experience immediate and long term effect of air pollution from artisanal processing activities or in the cause of destruction of the facilities by security agencies that could blow up stored raw materials and products. pharmacies supply medicines and medical laboratories provide routine and emergency sampling and testing.
- Divers: they are required to inspect and salvage sunk boats, tugs and barges. The services of professional divers and equipment are in high demand due to poor integrity of tug boats and barges available at rates affordable to hiring parties.
- Welders and Craftsmen: they carry out all the construction and maintenance work at the locations. It would seem they are entrusted with the fabrication. They are therefore, a focal point for changes and require some compulsory training and certification to enhance HSE and pressure code compliance.
- Host Communities: No activities at any location can proceed without the consent, buy-in and permit of the host communities. Perhaps the level of air and water pollution could have been minimised or eliminated with the education and training of local council technical officers and host community members on safety and environmental design specifications and regulations.
- Suppliers: food, water, drinks and technical supplies are ferried in as required from the nearest cities.
- Product certification services: this is provided by ISO certified laboratories for buyers.
- Industrial chemists and technologists: they provide product quality improvement services using additives
- Tank farm operators: this is a purely commercial arrangement with adequate documentation to meet regulatory requirements.

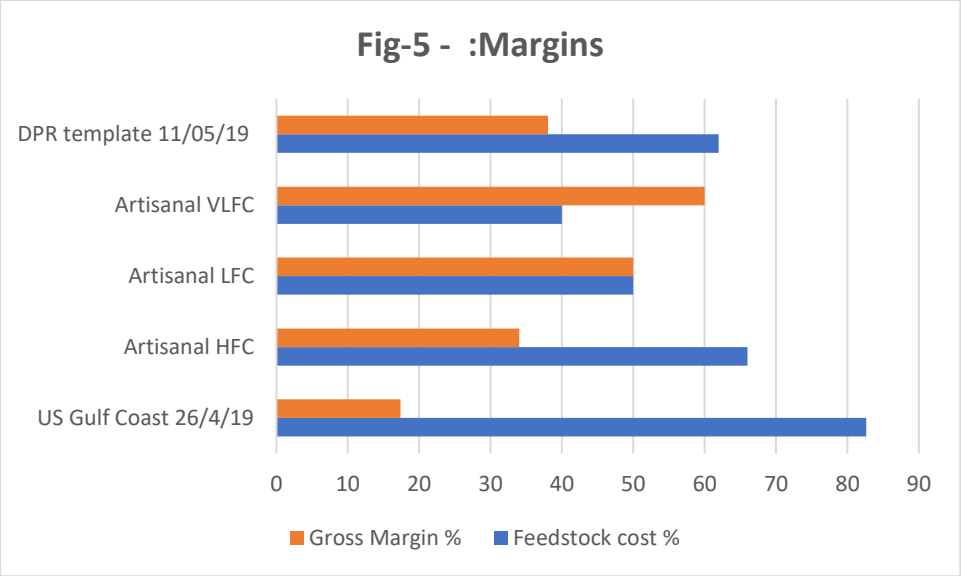
Margins

There has been lots of controversies on profitability and margins. A survey in 2019 was made on diesel suppliers and interview of artisanal crude oil refining actors from some communities in Abia and Rivers states and the findings are as shown in Fig-5 that follows:

- Artisanal crude oil refiners claim that the crude oil they process is purchased from another group and that they are not involved in pipeline crude oil theft. Definitely crude oil is purchased at a discount (distressed commodity) from the criminal cartel. There may also be collaboration between these groups. The gross margin covers fixed and variable operating costs on freight, security, hired equipment and other costs, and a cash operating margin. It is important to note that the gross margins for artisanal refining are estimates which can change from location to

location and time to time for High Feedstock Cost (HFC), Low Feedstock Cost (LFC) and Very Low Feedstock Cost (VLFC) scenarios.

- US Gulf coast gross margin include fixed costs, variable costs and cash operating margin. The spot market gross margin was based on 26th April 2019 Brent crude oil at price of $72.93/bbl and varies from month to month and year to year depending on feedstock prices, geopolitics and other factors.
- The DPR gross margin was based on 11th May 2019 Bonny light crude oil at $78/bbl for the 100 bbls/d -10,000 bbls/d modular (mini) refinery template on page 15 in the DPR 2018 Nigerian oil and gas industry annual report
- It is understood that pipelines loss of crude oil is under the Leadership and business control of the oil company operators. It is a serious national issue because government owns 60% of these losses. The biggest threat to the nation is crude theft for sale outside the country by an international cartel.



Source: DPR, OGJ, Survey feedback

Process intensification

There is an ethical dilemma on how crude oil is obtained and sold or utilised which has denied any serious technological improvements and investments in artisanal refining. It has also kept off competent professionals and companies capable of providing innovation. It is argued that the product of what is illegal remains illegal, and will also infect/ affect other legitimate products it's products are blended with to meet the specifications of an acceptable product(s). Also artisanal processing is done in non-compliance with health, safety and environmental requirements and regulations. Land or marine transportation of the products would depend on operators successfully getting appropriate permits from the applicable authorities because of the high security surveillance in place.

Current practices in the artisanal refineries tend to burn fuel oil and crude oil in the furnaces with natural draft that does not meet the stoichiometric fuel / air ratio. Cooling is also inefficient with the water jackets used. Unfortunately, incomplete combustion takes place and results in soot (carbon particles) as airborne pollutants. Depending on the wind direction, these particulates are dispersed to places remote from where the soot is generated.

Simple change of furnace burners to gas burners using portable LPG cylinders will produce cleaner combustion products. It is also possible to use electrical heaters, pumps and cooling fans with power supplied from solar panels and inverters and introduce simple temperature, level and pressure monitoring and control technology in the processes used, which will also improve safety. There are cost-effective process intensification technological options available to the artisanal refining activities consistent with the scale of operation and design codes compliance which have not been exploited, that could mitigate the environmental pollution, safety and quality control challenges associated with their current practices. Relying on aspirational ethics as argued by Mark Crawford (2012) and Harris C.R (2013), it is necessary to suggest arms length incremental pollution abatement features to protect the health and safety of the population and reduce green house gas emissions. This will secure improved longevity and reduction in cancers and respiratory diseases for the present and future generations (population) of the localities.

Instead of the cycle of frequent building and destruction of artisanal refining sites by setting the sites on fire and causing more air pollution (smoke) from carbon particulates from incomplete combustion, it will be more beneficial to assess their capacities, identifying appropriate equipment and processes for improvement and treat them as a potential equipment technology market

customers and hold the operators accountable (charged to court) for taxes, cost of feedstock and remediation of sites at close out of business voluntarily or involuntarily due to non-compliance with regulations .

Table-3: Risk exposures

Risk	Description	Consequences	Mitigation
Environmental (Air, water, land)	Unrestricted release into the atmosphere of gases; methane, ethane, propane, butane, pentanes and carbon particulates (soot) River water pollution from drains, oil stained washings and marine transportation spillages Ground and underground water pollution from oily product seepages into the soil	Damage to ozone layer from green house gases, Respiratory diseases, bronchial symptoms, carcinogens, mutagens, skin damage, blood disorders, reduced immunity, reproductive disorders. Damage to the ecosystem, fish nurseries and habitat, farms and the vegetation	Enforce existing regulations and directives
Safety of personnel	Workers exposed to flash fires due to charged high temperature atmosphere and without protective equipment. Lifting of heavy loads over long distances from sites to and fro load in / out water fronts without aid of lifting equipment	Hyenia, suffocation, burns of various degrees, injuries and accidents from fatigue	Enforce personnel protective equipment and HSE guidelines
Security	Regular security patrols to destroy illegal refining and storage drums	Total loss of investment, arrest, detention and prosecution	Avoid illegal activities
Public health	Deteriorating medical conditions of all age groups	Respiratory diseases etc	Improve socioeconomic conditions and stop illegal activities
Financial	Beneficiaries could be on the tracking list of the Nigerian Financial Intelligence Unit (NFIU) that monitors financial movements (in and out flows)	Frozen accounts and confiscation of funds	Avoid illegal activities
Reputation	Reputation is very valuable and vulnerable in business relationships and trust worthiness checks	Reputation could be damaged	Avoid infection and illegal activities

Regulatory practices and constraints

Nigerian upstream petroleum regulatory commission (NUPRC), Nigerian midstream and downstream regulatory commission (NMDRC), Ministry of Environment and their subsidiaries oversee specific components of the oil industry.

The roles include regulations and monitoring of the oil and gas industry activities ensuring that best practices and standards are complied with in design, construction, operations and maintenance. The regulator is expected to implement government policies and legislations that have been passed into law and has to collaborate with security and law enforcement agencies and the judiciary to achieve the regulatory and monitoring mandate. This includes interdiction and prosecution of offenders. In the USA, pipeline operators are required to comply with code of federal regulations (CFC) 49 on pipeline transportation, parts 178 to 199 in developing the infrastructure. Pipeline security guidelines are also issued to operators depending on the imminent threats and the current threats are more on cyber attacks. In Mexico, PEMEX has capability to detect a pipeline tap and its location within minutes with a combination of technology and ethical determination, which enhances the safety and profitability of the pipelines operations. In a situation where bad eggs within security agencies are directly or indirectly active in collaboration with actors carrying out unacceptable operations and activities makes the Regulator and perhaps the Operators helpless and ineffective.

The oil and gas operators should carry out vulnerability assessments, improve security plans, develop specific deterrent and protective actions. Review , develop and implement security response and recovery plans that address pipeline crude / products theft. Continuously monitor right of ways and improve appropriate system controls and from time to time test the effectiveness through exercises. Screen and conduct employee background checks, ensure regular and frequent inspection of pipelines to avert, detect and eliminate valved insertions on crude oil pipelines and “embark on a deliberate program to replace aged or compromised pipelines (Ogbuigwe A, 2018)”.

As noted by UNCTAD (2018) and UNDP (2019), “ innovation takes place in a complex system. While entered on firms, the national innovation system encompasses research and education systems, government, financial and regulatory bodies, civil society and consumers. The effectiveness of the national innovation system and technologies rests very much on the capability of these actors, the connections among them and the enabling environment for innovation that they create “.

Conclusion

Oil and gas Operators should adopt enhanced surveillance, improved leak detection system capabilities, increase the awareness of the pipelines crude oil theft problem with their staff, contractors, law enforcement authorities and enhance their capabilities for fast response and quick repairs.

There is a market and attractive differential in product prices for diesel and household kerosene from artisanal refining. This market has to be resolved and close the price differential by making available cheaper kerosene and diesel products. Power supplies need to be steady and adequate to support businesses at any scale as currently the market for diesel is high in running private and industrial generators. Alternatively, provide channels for buying crude oil as a commodity from the water-fed deports and other stations that may be found suitable. Develop cheap economical model plants, scalable, meeting design codes, health, safety and environmental requirements, that can be used to process crude oil and other derivative products on artisanal modular scale. This will formalise and capture their activities in the tax net, create employment for interested youths and provide training on suitable and sustainable skills. In addition, provide a minimum safety net, that can give the unemployed youths a choice and chance to be responsible, accountable, creative and innovative outside criminal activities.

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